ROADS AND STREETS

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Grade Separation on Bonaparte Outer Drive, Wayne County, Michigan, Showing How Sodded Slopes, Shrubs and Trees Form a Fitting Background for Grade Separation Structure

Roadside Beautification—A Glimpse Into the Future

A Practical Plan for Roadside Development

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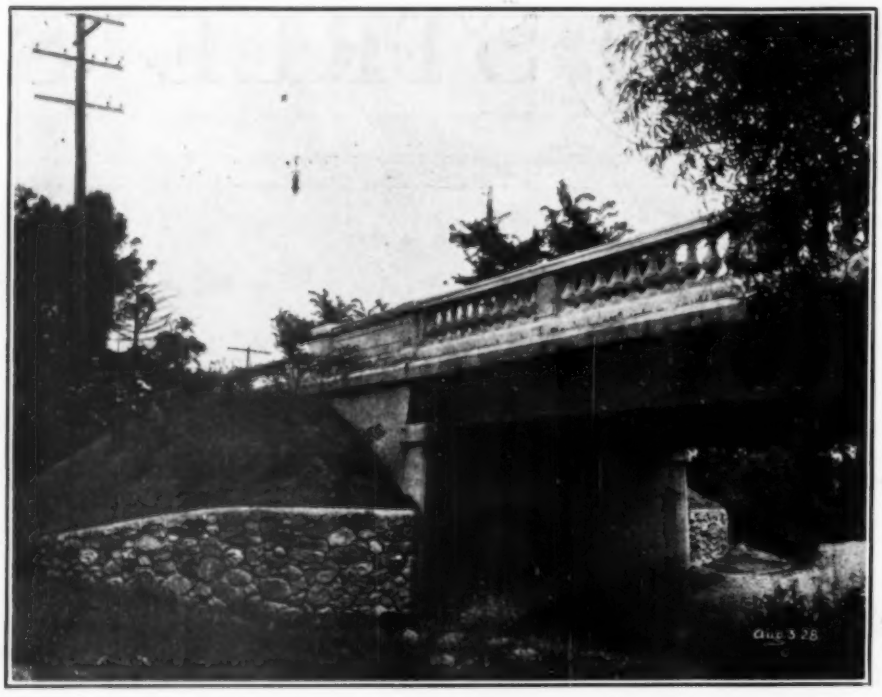
THE primary reason for constructing a road is to accommodate traffic. The extent of this accomplishment is measured in terms of service to the public. Roadside beautification or roadside development contributes to this service by providing the final necessities in safety, comfort, convenience, and appearance for the motorist. This is accomplished by the erection of direction signs, highway lighting, regulation of public utilities, maintenance of existing trees, planting, seeding and sodding, and the construction of comfort stations.

Need for Single Plan.—In a number of states departments of conservation and forestry cooperate with the highway departments in the work of planting roadside trees. Various shade tree commissions in some eastern states participate in a similar manner. In most localities the financing and part of the work of tree planting is left to public-spirited organizations and individuals. While these methods have accomplished a great deal the ultimate success of this phase of the work is dependent upon the highway authorities assuming full jurisdiction and responsibility. The practical importance of roadside development as viewed from all angles is sufficient to warrant its inclusion at least to some extent in every highway improvement program.

Since the main function of roads is to provide for traffic all other improvements, including the installation of overhead and underground public utilities and the planting of trees, should conform to a single plan as adopted by the highway authorities. For this reason the work of roadside development should be done or supervised by highway departments rather than by outside agencies.

Many highway departments carry on various phases of this work through their construction or maintenance divisions. If, however, a complete program is to be adopted a separate division should be created. Due to the fact that it is often difficult to make a definite distinction between some parts of



Rip-rap Walls, Sodded Slopes and Shrubs at Farmington Road Bridge, Wayne County

highway maintenance and some parts of roadside development it is essential that inter-departmental cooperation be maintained. The details of the division, however, should be worked out according to the requirements of the organization as a whole.

Ultimate Objective Must Be Considered.—No work should proceed without plans. Definite plans on paper are not always necessary, yet the ultimate objective must be considered in all cases. A complete cross section should be worked out for each road showing the present and ultimate location of the pavement, ditches, underdrains, poles, underground conduits, trees, and sidewalks, or paths. All of these improvements may not be installed for many years. The possibility of their use, however, should govern the location of trees. Under normal conditions trees will live for several generations and if they are to be planted now some consideration must be given to the future location of other improvements. In a number of cases the right-of-way is too narrow to permit the planting of trees and shrubs. The proper location of poles and underground structures will then demand the most attention. Generally sufficient space is available for trees on roadways of 66 ft. or more in width.

Formal and Informal Designs.—The landscape design of a road may be formal or informal, depending upon the width of right-of-way and the location. A formal design refers to trees planted in straight rows and shrubbery placed in uniform beds. This type of planting should be used where lack of space prevents informal planting and through cities and villages.

Informal design refers to trees and shrubs in natural arrangement not having the appearance of being planted by man. Spaces should be left along the road which afford pleasing views to the surrounding country. This type of design is recommended through rural districts where the right-of-way is of sufficient width to permit such variations.

Due to lack of space it will be found necessary in most cases to plant trees in straight rows. When this is done it is not necessary to make a planting design on paper. The number of trees required will depend upon the spacing used and this can be checked by means of a speedometer. Field notes taken at the time of checking will furnish sufficient information for planting.

Landscape plans should be made for the planting of all shrubs and for the informal planting of trees. Original road, bridge, and grade separation plans may be made use of for this purpose. This saves considerable work, both in the office and in the field. Architects' drawings and planting plans should be made for comfort stations and their surrounding grounds. Plans should also be made for small triangles at intersections and for odd pieces of right-of-way along the road. Where planting is practiced to any extent it is desirable to employ a landscape designer. In all major planting projects the location of trees and shrubs should be indicated by stakes.

Signs and Roadside Development.—The erection and maintenance of direction signs is usually taken care of by highway maintenance departments, although it may be included in roadside development. Uniform signs should be placed at all important intersections indicating directions and distances to principal points. Such signs should be as ornamental as practicable and the posts may be of wood, concrete, or steel. Sheet steel or wood may be used for the signs. Each complete post should be repainted at least once each year. In some instances it may be desirable to light these signs.

Advertising signs should not be permitted within the limits of any highway right-of-way and all such signs which obstruct views at railroad crossings or intersections should be removed whether they are on the highway right-of-way or not.

Mature Sugar Maples on Huron River Drive, Wayne County

Highway Lighting. — All improved highways should be lighted and three general methods may be employed for this purpose. They are: overhead center suspension, lights placed on a single pole line between two strips of pavement, and ornamental light posts with wires placed underground.

Overhead center suspension lights are placed directly over the center of the road and about 30 ft. above the surface of the traveled way. The lamps are suspended from span wires attached to poles on opposite sides of the road. Six hundred candlepower lights should be used spaced at from 350 to 450 ft. apart. This type of lighting may be used for pavements up to 40 ft. in width.

When two one-way drives are constructed lights are often placed on poles which are located in the center midway between the two roadways. The light poles are usually spaced about 115 ft. apart, each light reflecting with the traffic on both drives. Six hundred candlepower lamps should be used, placed at a height of 30 ft. above the ground.

Ornamental light posts are of various sizes and types and they are placed on each side of the road, either in an alternate or opposite position. The lights are fed by underground conduits, thereby eliminating the necessity for overhead wires. Posts placed in opposite positions should be spaced from 150 to 200 ft. apart. An alternate arrangement is most economical for the reason that a more equal distribution of light is secured with fewer lamps. Posts should not be less than 30 in. from the back of the curb and the lamps may be of from 600 to 2,500 candlepower with a mounting height of from 15 to 24 ft.

Comfort Station No. 3 on Telegraph Road, Wayne County

In some locations ornamental lights are suspended from mastarms placed on rustic cedar poles. Various types of cast iron, concrete, and fluted steel poles are also used. From the standpoint of appearance ornamental light posts are the most desirable.

Regulation of Public Utilities.—One of the most important phases of roadside development is the proper regulation of public utilities. These companies function for the benefit of the public, yet they should not interfere with the construction or use of the highways. Roadside trees often have to be trimmed to provide clearance for wires. In a number of states laws have been passed which prohibit unnecessary damage to such trees. Abutting property owners who hold deeds to the center of the road may object to this damage and they have the right of recovery in the courts.

It is necessary to construct and maintain power and communication lines and it is also apparent that most highways can be used for this purpose. The best service to the public is rendered in this regard through proper cooperation between the road authorities and the public utility companies. It is evident that highway authorities should regulate these companies, at least to the extent of specifying proper locations and in some cases types of construction. Regardless of the unquestioned right of some companies to the use of the highways, providing there is space for them, they should all secure written permits from the proper road department before setting new poles, rebuilding old lines, and trimming or removing trees. This furnishes an opportunity for the road authorities and the public utility companies to work together so that the entire road right-of-way may be developed in the best manner possible.

From the standpoint of safety, economy, and appearance the number of poles on all roads should be reduced to a minimum. Only two lines of poles should be permitted, one side of the road being used for power or supply lines and the opposite side for signal lines. This arrangement necessitates joint construction where two or more supply or signal lines are considered.

Shrubs, Trees and Grass on Five-Mile Road Development, Wayne County

The elimination of poles by this method constitutes a practical form of forest conservation or economic utilization of timber.

Trimming trees for wire clearance should be done according to the specifications of the highway department. Trees should never be topped and all cuts should be made flush with the remaining trunk or branch. The practice of rounding trees to artificial shapes to prevent line interference should not be permitted. It is always possible to string wires through trees and obtain sufficient clearance. Side arming or alternating the location of poles often aids in preventing tree damage.

Maintenance of Trees.—The maintenance of existing trees is an important part of roadside development. Trimming and light repair work should be practiced as found necessary. Before a new road is opened to traffic all dead and dangerous trees should be removed and all other trees properly trimmed. An unobstructed view to approaching cars of 250 ft. should be provided for at all important road intersections. A similar view of at least 500 ft. should be left at railroad crossings. Where curbs are not constructed trees should not be left closer than 5 ft. from the edge of a 20-ft. pavement or 3 ft. from the edge of a 40-ft. pavement.

The proper trimming of all existing trees adds to the appearance of the roadsides and lessens the danger from falling limbs. In trimming, all dead and interfering branches should be removed. The natural shape of each tree should be preserved as much as possible, according to the species. Trimmers should start at the top of each tree and work toward the ground. The use of safety belts and rope swings in the place of ladders is recommended, as they provide for safer, faster, and better trimming. Ladders are often necessary, however, to reach the lowest branches. Spurs should never be used, as they are injurious and unnecessary. All cuts should be painted with an approved brand of tree paint of an inconspicuous color.

A trimming crew may consist of six or ten men with one foreman and a truck driver. A 3-ton flat bottom truck, equipped with pneumatic tires and capable of making a speed of 35 miles per hour, is most desirable. All necessary small tools, ladders, and the crew may then be easily transported. Most trimming jobs are small and often far apart and since the equipment is light a speedy truck is desirable in order to save time.

Extensive cavity work or tree surgery should be practiced only in rare instances, as it is a costly procedure and rather unwarranted in connection with trees along country roads. It is often advisable, however, to do a certain amount of bolting or bracing in order to preserve unusually fine trees. Bolts may be placed through the trunks of trees at dangerous crotches and limbs may be supported by means of cables. Cables or wires should never be wrapped around a limb or trunk but should be attached to bolts or lag screws. This avoids killing the branch or tree by girdling.

The spraying of existing trees should be practiced twice each year in order to control insects and diseases. Spraying as a preventive will usually check any outbreak which after occurring would be difficult to control. Oil emulsion is applied during March for scale insects and diseases. Arsenate of lead may be used in early June for leaf-eaters. A high powered spray machine delivering a solid stream to a height of one hundred or more feet in the air is best for mature trees.

Selection of Trees and Shrubs.—In planting trees and shrubs the most desirable species should be used with reference to hardiness, immunity to insects and diseases, rate of growth, and appearance. Species should also be selected which will grow well on the type of soil at hand. Norway maples, sugar maples, American elms, red oaks, pin oaks, and American sycamores, are used mostly in this section of the country. Trees from 2½ to 3 in. in diameter are most economical to plant.

It is usually inadvisable to establish a municipal nursery. Trees can be purchased from nurseries at a cheaper rate than the cost of producing them in a public nursery. A storage yard should be maintained, however, where trees can be unloaded and heeled in until ready for planting. Excess material may be carried over in this yard and also a few species grown which cannot be purchased elsewhere.

Only nursery grown trees should be used. Trees growing in the fields or woods have never been cultivated and root-pruned and their roots extend over a large area. In transplanting such trees many roots are lost and the percentage of tree loss is high. The culti-

Elms Planted in Spring of 1925 on Middle Belt Road

Removing Tree on Dix Road, Congested District

Elms Planted in Spring of 1924 on Ford Road

vation of nursery trees forces a compact root growth underneath the crown which is almost entirely retained in transplanting. Also the labor cost involved in digging and hauling field grown trees is greater than the price paid the nurserymen, including freight.

Planting Trees and Shrubs.—All trees should be selected and tagged at the nurseries. Shipments should be made in car load lots in the fall, after the leaves drop or before the buds burst in early spring. In the northern states on heavy soils which are subject to freezing and thawing, trees should be planted in the spring. Evergreens, oaks and sugar maples usually get a better start when spring planting is practiced.

As trees are unloaded they should be inspected for insects or diseases, root pruned and top pruned, roots dipped in a tank of mud and water, and heeled in. If infected trees are found they should be segregated and the nursery notified. Broken roots and tops should be removed and the branches thinned or cut back sufficiently to form a balance between the roots and the top. Leaders should seldom be removed. All cuts should be made just ahead of a live bud and care should be taken to preserve the natural form. As soon as the trees are heeled in in trenches they should receive a dormant spray of oil emulsion as a precaution against scale, insects and disease spores.

The same type of truck used in trimming may also be used for planting. Trees should be loaded with their roots against the cab and tops to the rear. Wet straw should be packed around the roots and then covered with a heavy canvas. This prevents wind drying the roots as the trees are transported to the job. Planting should proceed directly from the trucks. If the trees were distributed along the road and the roots allowed to remain exposed for even a short time on a dry or windy day they would not survive. The number of men in a planting crew depends upon the number and size of trees planted and the number of trucks engaged in hauling.

The method of handling shrubs is about the same as that of trees. Native shrubs should be used throughout the open country, depending upon types of soil. Through cities or villages cultivated shrubs are often desirable. All shrubs should be purchased from nurseries in sizes ranging from one-quarter to one-half of their mature size. Many nurseries dig shrubs in the fall and store them in cold cellars over winter for spring shipment. It is inadvisable to purchase shrubs handled in this manner, as their progress in the spring is retarded. Only freshly dug material should be used.

All trees and shrubs which do not survive should be replaced the following planting season. A simple record should be kept of all material planted, as among other things it is an aid in determining the number of replacements required. The total loss of any planting should not be more than 10 per cent.

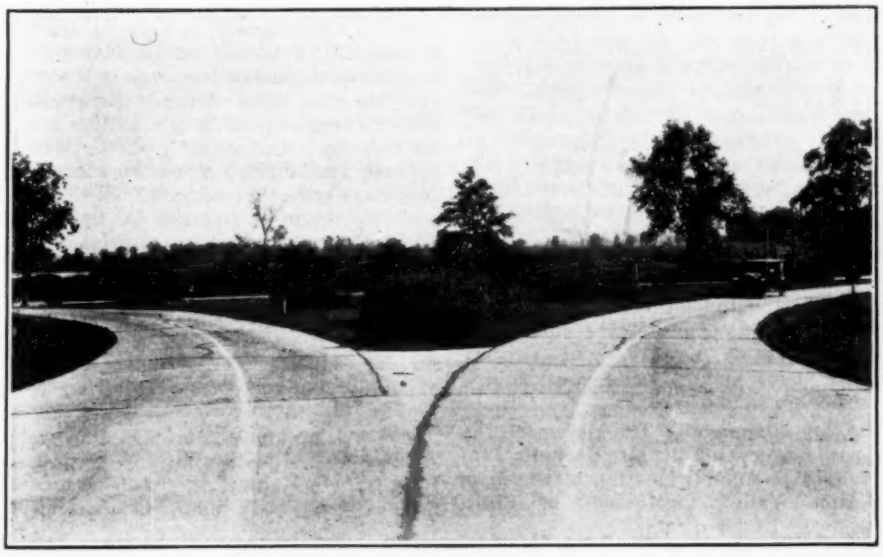
Seeding and Sodding of Slopes.—The seeding and sodding of road shoulders and slopes through cuts and fills adds to the appearance of the roads and prevents erosion. It is usually cheaper to cut the grass than to continuously fill washouts. Bare spots which are level may be successfully seeded while all slopes should be sodded because of grass seed washing from slopes before growth starts. Various mixtures of grass seed may be used, depending upon the type of soil. It is better to purchase the seed separately and mix as desired than to buy seed ready mixed. A better quality is obtained in this manner and the proper kind insured for the soil at hand. The most common grasses used are Kentucky blue grass, red top, June grass, perennial rye, and white clover. Seed should be sown at the rate of about 100 lb. per acre.

The sodding of slopes at bridge ends, through grade separations, and along heavy cuts and fills practically eliminates washing of the banks. When slopes are sodded through cuts it usually is necessary to install a system of underdrains to prevent water from coming through the bank. Sod will not remain fixed on slopes which are constantly wet. A sandy loam sod from old pasture fields is best for this purpose. It should be removed with a sod cutter drawn by a rubber tired tractor and should be not less than 2 in. in thickness. It is most easily handled when cut in convenient sized squares.

Sodding should start from the bottom and proceed toward the top of the slope. After all sod has been placed it should be firmly tamped or rolled in place. Grass seed sown over the sod before rolling aids in establishing a solid, compact surface.

Comfort Stations.—Modern comfort stations along main traveled highways add much to the comfort and convenience of the motorists. These buildings should occupy areas adjacent to the road right-of-way with ample space provided for parking. While fireproof construction is most desirable, the cost is much less where wood is used.

To provide everything in proper service a comfort station should be equipped with rest rooms, hot and cold running water, toilets for men and women, heat, public telephone, information booth, first aid supplies and electric lights. Such buildings should not be constructed where running water is not available. Dry toilets are undesirable and dangerous regardless of precautions taken. Septic tanks for sewage disposal are recommended when sewers are not available. A caretaker should be in attendance both day and night and the entire building kept constantly clean.



Treatment of Parkways at Middle Belt Intersection on Huron River Drive, Wayne County

There is little question as to the necessity or desirability of roadside development. Orderly and attractive roadsides are more easily maintained than those which are undeveloped. They are a benefit to abutting property owners as well as to the community at large. What could be more representative of the success and prosperity of any district than the complete development of its roads? Newly constructed roads should be delivered to the public as a manufactured product which if sold without proper service would be a failure. Since automobiles furnish the most popular means of individual transit, the necessary features of safety, comfort, convenience, and appearance must be provided in good roads equal to or greater than that offered by any other transportation system.

What Wayne County Has Done.—The brief outline of roadside development as given here is not merely a collection of ideas or a visionary plan to be carried out at some future date, but a practical plan which can be suc-

cessfully worked out in its entirety or in part by most any state or county. Since March, 1922, the Board of Wayne County Road Commissioners has accomplished the following: 250 miles of road planted with 35,000 trees ranging in size from 2½ in. to 6 in. in diameter; 40,000 shrubs planted; 130,000 sq. yd. of sod placed; 20 acres of bare spots seeded; trees trimmed on more than 500 miles of road; all trees sprayed twice each year; 700 permits issued for construction of pole lines; 650 permits issued for trimming trees; 175 permits issued for removing trees; 3,000 public utility poles eliminated by joint construction; 12 fireproof roadside comfort stations erected, containing every modern improvement. The organization is a division of parks and forestry whose head is responsible to the engineer-manager. It includes six graduate foresters, one graduate landscape designer, and approximately 130 men, including superintendents, foremen and caretakers. This force is reduced to about 55 men during the winter. The equipment consists of seven trucks, several tractors, five spray machines, motor mowers, and various small tools and miscellaneous equipment.

Acknowledgment.—The foregoing is a paper presented by Mr. Bennett, Jan. 11, at 21st Annual Meeting of the Mississippi Valley Conference of State Highway Departments.

State Highway Maintenance in Tennessee

General maintenance of the entire state highway system of Tennessee was instituted by the Department of Highways and Public Works in July, 1925, although prior to that time (since May, 1923), the department had been maintaining several of the principal trunk lines of the state. Some interesting facts regarding the maintenance procedure are given in the recently issued report of Harry S. Berry, Commissioner, covering the biennium ending June 30, 1928.

At the present time the department is maintaining approximately 7,000 miles of highway. Included in this mileage are 1,411 miles of high type pavement, 1,192 miles of intermediate type pavement and 4,397 miles of gravel macadam and earth.

The entire state is divided into maintenance sections, each section being in charge of a patrolman, who is directly responsible to his district maintenance engineer for the character and quality of maintenance in his section. The length of these sections varies, depending upon the type of surface, the traffic on the highway and the location of county line. The average length of a maintenance section at present is approximately 12 miles.

The maintenance of stone, gravel and chert roads is accomplished by continuously moving with a grader a floating layer of fine stone, gravel or chert. The graders are all motor propelled, one-man outfits being in most general use. By continually dragging this floating layer of material a remarkably smooth riding surface is produced and maintained.

For the maintenance of macadam, gravel or chert roads, it is necessary to keep at all times on the surface of the road a layer of fine material, generally composed of the same class of material as the road itself, varying in size from ¼ in. to 1½ in. as a floating layer. In Diviisons 1, 2, 3 and 4, there is generally available an ample supply of natural limestone, gravel or chert. The material used depends primarily upon the economy of its production and distribution. On account of its more general availability, more limestone is used than any other material. It makes probably the most material for the purpose, also. Nearly all material used for floating layer in Divisions 1, 2, 3 and 4 is produced by the state. This necessitates the constant use of a large number of rock crushers, air compressors and drills. Very reasonable cost of production has been obtained with these outfits, however.

The well maintained macadam, gravel or chert road makes a very pleasant riding surface, until the dust becomes bothersome. This point is generally reached when the traffic count reaches 300 vehicles per day. The department has undertaken to meet this problem by the application of surface treatment on those routes that are not in contemplation for early paving, and which have produced sufficient traffic to justify the expenditure necessitated by surface treatment. The method of surface treatment used in Tennessee is an adaptation of the method used by the Pennsylvania Highway Department. This method consists of a double treatment with cold bituminous material using stone chips ranging in size between ½ in. and 1½ in. The road is carefully dragged with a grader during the process of construction, and the result of this is the production of an exceptionally smooth riding surface which is also practically non-skid. The cost of the treatment itself will average approximately $2,200 per mile. In addition to this cost the roads are generally widened, new stone or gravel added to the base and the drainage structures replaced or rebuilt where necessary, before application of the surface treatment itself. The cost of this construction will vary with the width and condition of the road. On the roads so far treated, however, it has averaged about $1,000 per mile. The first treatment of this type was done in May, 1925, on State Route No. 35, Knox County. During 1925 approximately 50 miles were surface treated. At the present time there are approximately 1,192 miles of this type of road on the Tennessee highway system and of this mileage approximately 400 miles were built in 1927, and 600 miles in 1928. Considering its cost, the surface treated road has given excellent and economical traffic service.

In addition to the work previously outlined, the maintenance force has covered with stone, gravel or chert, approximately 500 miles of road, which the department has graded on permanent location. Approximately 1,000 tons of stone, gravel or chert per mile are used in this work, and the cost varies from $1,000 per mile to $3,000 per mile, in sections with long haul and imported material.

Reconstruction of several hundred miles of county roads, added to the state system during 1927 and 1928, has been completed or undertaken by the maintenance force. This reconstruction consists of widening, re-locating, installing drainage structures and macadamizing.

The maintenance force, in several places, has also been engaged in the construction of grading and drainage projects on permanent location. A great deal of this work is located in the mountains and involves the use of steam shovels, with very heavy yardage to be moved.

At the present time, all patrolmen on maintenance sections report directly to the district maintenance engineer, who is charged with the duty of supervising all maintenance within his territory. At the present time there are five maintenance districts in each division and therefore twenty-five in the entire state. The division maintenance engineer, under the supervision of the division engineer, is charged with the responsibility of all maintenance work in his division. The state maintenance engineer reports to and is directly responsible to the chief engineer, and he is charged with the responsibility of seeing that maintenance of uniform quality prevails throughout the entire state, and that uniform methods are used in each of the five divisions of the state. He must study all methods of maintenance used in this and other states with a view of attempting to use the best and most economical methods that may become available from time to time, as knowledge improves, uniformly in the maintenance of all the roads of his state.

Pennsylvania State Highway Mileage.—Pennsylvania's highway mileage under state control totals 13,330 miles, 12,750 miles of authorized system and 580 miles of state-aid, according to official figures of the Pennsylvania Department of Highways. About 8,830 miles are hard-surfaced and the remaining 4,500 unimproved or slightly improved includes 1,214 added July 1, 1928, by an omnibus bill enacted in 1927.

Nature, The Great Mathematician

By HALBERT P. GILLETTE, Editor

NATURE is mathematically-minded. Her fundamental motions are regular curves and she designs in geometric patterns.

Perhaps the first man to recognize this fact most clearly was Kepler. At any rate, he spent most of his life searching for mathematical laws, often searching in a manner that suggests blind groping, yet always guided and inspired by unwavering belief in Nature's geometricity.

Failing to see that Kepler was thus guided in discovering that planetary orbits are elliptical, John Herschel said: "This (thing) Kepler accomplished for Mars, which he ascertained to be an ellipse having the sun in one of its foci; and the same law (path?) being extended by inductive analogy to all the planets, was to be verified in the case of each. This, with the other remarkable laws which are usually cited in physical astronomy by the name of Kepler's laws, constitute undoubtedly the most important and beautiful system of geometrical relations which have ever been discovered by a mere inductive process, independent of any consideration of a theoretical kind."—Herschel's "Discourse on the Study of Natural Philosophy."

But were Kepler's discoveries "independent of any consideration of a theoretical kind?" My conviction is that he was guided by a theory of the most potent nature—the theory that Nature is mathematical; and I find that a celebrated scientific writer of Herschel's day, William Whewell, held a similar opinion, for he said: "His (Kepler's) habit of devising so great a multitude of hypotheses, so fancifully expressed, had led some writers to look upon him as an inquirer who transgressed the most fixed rules of philosophical inquiry. This opinion has arisen, I conceive, among those who have forgotten the necessity of ideas as well as facts for all theories; or who have overlooked the impossibility of selecting and explicating our ideas without a good deal of spontaneous play of the mind. * * * Among all Kepler's fantastical expressions, the fundamental thoughts were sound and true; namely, that it was his business, as a physical investigator, to discover a mathematical rule which governed and included all the special facts; and that the rules of motion of the planets must conform to some conception of causation."—Whewell's "Philosophy of Discovery."

While Whewell fails to state, and perhaps to see, that Nature is always fundamentally mathematical, he does recognize that Kepler was imbued with the idea that amid the apparent chaos of Nature mathematical law reigns. It was this generalization, based on relatively few facts and at that time scarcely more than an intuition, that acted as spurs to Kepler's ambition and led him to say: "The enemy (meaning the problem as to the orbit of Mars), left at home a despised captive, had burst all the chains of the equations and had broken forth from the prisons of the tables," but that "the war is raging anew as violently as before." And such a war! Many a year it raged before the planet Mars was finally fettered by an equation, the equation of the ellipse.

"Kepler constructed no less than 19 (hypotheses) for representing the apparent motion of Mars before that of an elliptic orbit about the sun suggested itself to his mind, which proved to be the true one, and the simplest of them all."—Herschel's "Essays."

A recent writer speaks of Kepler as being perhaps the greatest mathematical genius of all time. Only in a very restricted sense can Kepler be called a mathematician. He was not in the same class with Newton as a mathematician. But he was one of the most profound believers in the mathematicity of Nature. His was a series of prolonged efforts to discover a few quantitative laws of Nature by the process of "trial and error," which is analogous to the methods used by many physical experimenters and inventors. That was Faraday's method in experimenting. That is Edison's method in inventing. In none of these three men—Kepler, Faraday and Edison—do I find very profound mathematical ability, such as made Newton famous, such as should have made Willard Gibbs famous, and such as now makes Einstein famous.

Speaking of Faraday suggests my adding that he, too, was always guided by a theory, which, as I interpret his actions, was this: Nature repeats the same patterns in many forms and with changes that often seem greater than they really are. Hence any likeness between any two phenomena, however slight it may appear, probably indicates a profound kinship; and should be used as a guide in searching for a fundamental likeness.

If Faraday did not hold some such theory, why did he cling so persistently to his so-called intuition that electricity and magnetism are related phenomena, and why did he regard light as being an electromagnetic wave long before Maxwell proved it to be mathematically just that, and generations before Hertz proved it to be so experimentally and thus led to the invention of radio-telephony?

As we study the methods of such discoverers we learn that they all were guided by certain beliefs that have been usually called intuitions. An intuition is a mysterious thing; and refusing to be impressed by mysteries, I prefer to seek an explanation that contains no mystery. So I would substitute for the term "scientific intuition" a term that strips away the magic. I would call it reasoning by aid of slight, even tenuous, analogies, or, briefly, analogical guidance.

It was probably analogical guidance that led Kepler to believe in the existence of the mathematical laws relating to the orbits and velocities of the planets, which he discovered by dint of adherence to his belief.

It was probably analogical guidance that led Faraday to discover so many laws of electricity and magnetism.

Yet every book on logic warns the reader against reasoning by analogy! It sounds like warning a bird against using its wings. Birds, however, would not heed such a warning, whereas, most men have a way of heeding the utterances of those who speak authoritatively. Hence it may have happened that the disciples of Aristotle, the father of logic, have done more to retard than to hasten progress through thinking.

Weeds in Grassy Lawns Controlled by Lead Arsenate

More or less as a by-product of the campaign against the destructive Japanese beetle, entomologists of the U. S. Department of Agriculture have discovered a method of improving the turf of lawns and golf courses. Several years of experimental work have shown that lead arsenate mixed with the surface layer of soil will control even though it may not completely exterminate most of the hard-shelled beetles, including the Japanese beetle, and certain other soil inhabiting insects. Such an application will not harmfully affect the growth of the grasses commonly used in golf greens and lawns. Several varieties of bent, perennial ryegrass, Chewing's fescue, sweet vernal grass, meadow fescue and Kentucky bluegrass will thrive in the poisoned soil. On the other hand, the lead arsenate kills crabgrass, chickweed, dandelion, and dock, which are often so troublesome in lawns. The p o i s o n favors a much purer stand of the desirable varieties.

When the lawn is being made or a golf green prepared, lead arsenate may be mixed with soil at the rate of 1,500 lb. to the acre. One application at this rate has been found effective for about six years as regards the soil-infesting insects. To treat lawns already planted apply a top dressing of the usual fertilizers, adding 5 lb. of lead arsenate for each 1,000 sq. ft.

Mixed Oil-Gravel Roads

Methods of Testing and Control in New Mexico

By H. W. RICE

IN the study and development of oil roads, using 60 to 70 per cent asphalt oil, mixed with gravel under the specification of the surface mixed method, it has been learned that the same general principles govern these mixes as control asphaltic pavements. The principal difference appears to be in the amount of fuel oil required for binding purposes; so long as the correct amount of oil is used, it appears that wide variations in grading may be tolerated.

Formula Calculation. — The Division of Highways, California Department of Public Works, and the United States Department of Agriculture, have published an empirical formula, based on the mechanical analysis of the aggregates to be oiled, for computing the amount of oil required to properly bind the particles of sand and gravel in the road.

The formula is:

$$P = .015A + .03B + .17C$$

in which "P" is the per cent, by weight, of oil required, "A" is the per cent of metal retained on the 10-mesh sieve, "B" is the per cent of metal passing the 10-mesh sieve and retained on the 200-mesh and "C" is the per cent of material passing the 200-mesh sieve.

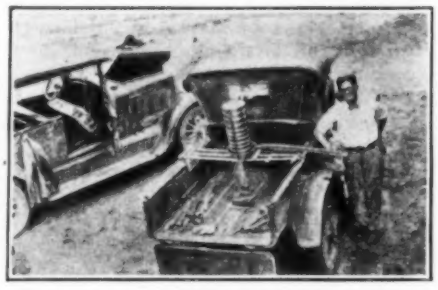
This formula has proven very beneficial to our work in New Mexico, but due presumably to the cooler climate here it is found necessary to increase the calculated amount of oil by 20 or 30 per cent, depending on climatic conditions and the nature of the material to be oiled.

Stain Test.—At this point a question is likely to arise as to what determines the amount that the calculated per cent of oil is to be increased and how to tell when the proper proportion of oil and gravel are obtained on the road. The most dependable, and in fact about the only index we now have to this, is the stain test, which is a modification of a test used in sheet asphalt work.

A sample may be prepared by mixing the estimated per cent of oil with the material to be treated, or if the material has been processed on the road, a sample may be taken from that. The fine material should be separated from the coarse by passing through a 10-mesh seive. One pound of the material passing the 10-mesh sieve is then heated by placing it in a can partially submerged in boiling water for one hour. The heated material is poured upon a white paper, leveled off, and covered by another sheet of white paper, and on top of this is placed a 2-in. wooden block. A 2-lb. weight is allowed to fall freely on this block from a height of 1 ft. for five strokes. The papers are then removed and the resulting stains on the paper given the indication desired.

By comparing the stains thus obtained with stains made from mixtures which have proven satisfactory, the desirability of the mixture can be ascertained.

Thorough Screen Test Necessary.—It will be noted from the above formula that the material passing the 200-mesh screen is the most critical factor in determining the amount of oil to apply, thus rendering it imperative that the sample be thoroughly screened and all of this dust shaken down if the results obtained are to be relied upon. The amount of dust in pit run gravel varies considerably, which calls for frequent sieve tests on the road material. Shaking a set of sieves by hand is not regarded by many as a very pleasant or desirable task and experience proves that the amount of time and vigor applied to this work is often less than necessary to obtain dependable results.



General View of Sieve Shaking Arrangement

A Field Mechanical Sieve Shaker.—With the above in mind it was desired to develop a mechanical sieve shaker for field use, which would give the screen a uniform and thorough shaking.

At the beginning of the Canoncito-Pecos Oiling Project the writer assembled a device for this purpose, using material on hand with the addition of a few odds and ends gathered from the scrap pile of a nearby repair shop. This source of material in part accounts for the crude appearance of the otufit.

The device was arranged to sit on the body of the Ford commercial roadster assigned to the project and was operated from the right rear wheel of the car. The illustration shows the general view of the shaker. A lath cradle was constructed to give a width of about 1 ft. and a length sufficient to span the width of the body on the Ford. A tin pan having an 8-in. bottom was nailed on top and at the center of the cradle just mentioned.

The nested 8-in. laboratory sieves were set in the pan and held in place by a leather strap fastened to the cradle and over the sieves. The cradle was held in position on the sides of the Ford body by a lath from each of its ends to small stakes fitted in the stake holes on each side of the car body. To actuate the cradle, one end of a stick was fastened to the cradle just to the right and in front of the pan and allowed to extend over the end of the cradle and outside of the Ford body, so that the outer end was over the right rear wheel of the car. The outer end of the stick was attached to the rear wheel of the Ford by a rod and piece of wire. The connection to the rear wheel was made to a crank arm by fastening, under the axle nut, an iron plate having a short crank shaft which was offset 1½ in. from the center line of the rear axle.

To give a decided jolt to the sieves on each stroke, a board was tacked to the back side of the cradle, so that it struck the floor of the Ford on the down stroke. To make the action more positive, a coil spring was wired to the cradle under the pan and fastened to the floor of the Ford body so as to give the desired tension.

The rear wheel was then jacked up and by setting the speed of the motor at the correct point, the apparatus gave the sieves a more efficient shaking than would be possible by hand. This apparatus has been working satisfactorily for the tests on the oiling work since it was made in August and the same device is still being used, except that it is now used on a Model A Ford instead of the old Model T shown in the picture.

Spreading of the Road Gravel.—In the beginning paragraphs of this article it is indicated that it is possible to calculate, within reasonable limits, the amount of oil which should be applied. As this amount is a per cent of the material to be oiled, it is essential that the gravel be spread to a uniform thickness and width. The oil distributors now in use are not capable of varying their output with sufficient accuracy to compensate for variations in the amount of the material on the road nor for its variation in grading. The oiling work is laid off in runs, or spreads, and the truck puts on the same amount of oil per unit of area throughout one spread. If the general average of the quantity of material or its grading changes, the rate of oil distribution can be changed to conform to that average; that is, the length of the run can be lengthened or shortened, and the sprays set so as to empty the oil tank while covering that distance.

It is quite apparent that uniform spreading and grading sizes are to be desired, but in practice it seems difficult to obtain either. It is quite probable that these features will be given more consideration in the future development of the surface mixing method.

Acknowledgment. — The foregoing article is taken from the January New Mexico Highway Journal.

Construction and Maintenance of Highway Bridge Plans

Experiences of an Indiana County

By H. D. HARTMAN
County Surveyor, Wabash County, Indiana

I REALIZE that each county may have its own peculiar conditions and practices as relates to bridges. Yet I believe that generally speaking, the problem of construction and maintenance of bridge floors is about the same in all other sections of Indiana, as it is in Wabash County.

Classes of Bridges.—There are three divisions into which I believe bridges may be properly classed. They are:

First: The filled concrete, stone or brick arch.

Second: The reinforced concrete flat top types.

Third: All steel truss or girder types as well as the open arch.

In the first division, the floor problem is practically eliminated, as it is merely a matter of constructing a type of road surface on the subgrade across the structure, the same as the rest of the roadway which it serves.

Those structures which have been designated as in the second division are likewise not likely to present any serious difficulty for the reason that no better floor could be devised, in my opinion, than the surface of the slab itself, the same needing only to be waterproofed and drained to make an excellent floor.

The structures mentioned in the third division, namely steel truss, girder or open arch types, are those in which we find our greatest difficulty not only as regards new construction but in maintenance as well.

How often de we see in our travels about the country, especially in those localities which are served mainly by secondary roads, those faulty and dangerous plank floors which have been neglected until they become a serious menace to traffic, sometimes to such an extent that said traffic is diverted to other roads, whereby causing great inconvenience and loss to the public.

Determining Condition of Bridges.—While I am speaking along this line I would like to suggest, that in my opinion, each county should have a definite and systematic plan of determining the condition of all bridges at stated intervals.

I believe that for a period of one or two weeks once each year, the county commissioners and engineer should examine all bridges in their county and promptly cause to be repaired or rebuilt, all those which in their opinion are in need of such repair or renewal. It is false economy to let inadequate or faulty bridge floors exist year after year, because in the long run such neglect results in a new structure which will cost far more than proper repairs made at the right time, to say nothing of the inconvenience and discomfort to the general public.

In Wabash county the majority of the bridges are in the third division mentioned above. In nearly all of these bridges the original floor consisted of lateral floor beams hung from the truss or girders and were spaced on the average about 16 ft. center to center.

Placed on these beams and running longitudinally were 3-in. by 12-in. oak stringers and on top of these stringers 3-in. planks were spiked, which formed the wearing surface.

Constructing Creosoted Wood Block Floors.—About 20 years ago the replacing of these old plank floors was commenced, and with few exceptions the creosoted wood block floor was adopted with a rearranged sub-floor structure.

The old floor is entirely removed from the bridge and all steel work thoroughly drawn up until all members have proper tension.

The entire structure is then thoroughly cleaned by the use of wire brushes, after which it is given two or three coats of graphite paint of acceptable quality.

There is then laid in place steel I-beams of proper dimension. These beams run longitudinally and are secured to the floor beams with ½-in. bolts. Beams are generally spaced 2 ft. center to center. It would seem at first thought that bolts would become loosened by vibration, but if bolting is properly done and paint is applied, there is not much chance of any loosening.

The two outside longitudinal members are steel channels of the same height as the I-beams.

In order to procure a satisfactory crown in the finished floor surface, steel plates about 5 in. square and varied in thickness, are placed under I-beams.

The thickest of these plates, generally 1 in., are placed under the center beam and the thickness of each line of plates is diminished towards the outside of the floor. The outside channel rests directly on floor beams. Steel plates are drilled for ½-in. bolts which secure beams to the bridge.

There is then bolted, at intervals of 4 ft., to the I-beams in the center, on the quarter and at the channels, nailing strips of 3-in. yellow pine. These strips run the length of the bridge and should be tightly drawn up with ½-in. bolts running through I-beams and strip. These strips are for the purpose of spiking down the 3-in. plank subfloor.

There is then laid on the I-beams and at right angles to center line of bridge—3-in. creosoted plank (not less than 6 in. in width), said plank to be spiked down to nailing strip with 60 D nails. At both outside ends of planks there is then bolted in place a 3-in. by 6-in. felloe guard to secure ends of plank. This felloe guard is bolted in place by ½-in. hook bolts which run through the guard and plank and hook under the channel. These bolts are placed 5 ft. apart and when drawn up tight they hold the plank securely in place. All lumber used shall be treated with creosote the same as floor plank.

On the surface of the creosoted plank there is then laid one layer of two-ply tar paper of good quality. The purpose of this paper is to prevent the hot pitch which is to be poured around blocks from running between planks. A heavy paper of good quality should be used for this purpose.

After paper is laid, it is given a light coat of pitch which is swabbed on while hot.

Laying the Blocks.—Creosoted wood blocks of acceptable design are then laid on the tarred paper in such a manner that joints of about ⅛ in. are left on all sides of the blocks to permit expansion and contraction. Blocks are laid at an angle of about 22½ deg. with the longitudinal center line of the bridge in order that no joint line in the blocks will coincide with joint in planks beneath. Blocks are not laid flush against felloe guards but there is installed between said guards and blocks a suitable expansion joint not less than 1 in. thick of the same depth of the blocks and running the full length of the floor. There are a number of good expansion joint fillers on the market and none but the best should be used. The item of expansion and contraction in block floors is an important one and should not be overlooked.

I have found, from experience, in laying block floors, that it is good policy after laying blocks and before filling the joints, to leave them lay for not less than 24 hours if possible, for the reason

that they will show a certain amount of shrinkage, especially when laid in warm weather, which will cause joints to open to maximum width and permit of a better job of sealing. In my opinion, block floors should be laid in warm weather to obtain the best results.

All joints in the blocks should now be filled with a suitable pitch filler to such an extent that about 10 lb. of filler will be used to each square yard of floor surface. The job of filling joints should be thoroughly accomplished in order that none will be left open and that a tight, waterproof job will be obtained.

The quality of pitch to be used may be any of the high grade pitch fillers now on the market. Pitch should be heated to such a temperature that it will pour readily and penetrate into all openings or crevices. Pitch shall be of such viscosity that it will not become brittle in cold weather, thereby causing it to chip or crack under traffic or too soft in warm weather, which will cause it to "bleed."

Following the filling of joints there should then be spread over the surface of the floor a thin layer of clean sand, say ½ in. in thickness, which is for the purpose of taking up all excess pitch which may exist on floor. This sand should be allowed to remain on floor at least two weeks and then the excess may be removed if so required.

At the ends of the floor the blocks may be held in place by steel Z-bars of the same width as the floor. These Z-bars should be bolted to ends of I-beams and should lap over the surface of a concrete backwall which is built on the abutment to support abutting roadway and make a satisfactory connection with bridge floor.

After sand is spread the bridge should remain closed about 24 hours, after which it may be opened to traffic.

Wabash County has had excellent success with the creosoted wood block floor. We have floors of this type which have been in use for more than 18 years and they are still in excellent condition and the maintenance cost per square yard has been negligible.

I realize, of course, that the foregoing specifications is for a structure which requires new steel throughout and a general sub-floor renewal. All bridges of this type, however, do not require all new steel and this of course cheapens the work to some extent.

In the study of any bridge, prior to making specifications for floors, the engineer should, by ingenious methods, utilize all old material possible in order to keep costs to a minimum.

Rebuilding Old Bridge Into Useful Structure.—It is not always necessary, of course, to adhere strictly to a standard specification for a type of floor. About four years ago in Wabash County, there was a bridge just outside one of our small towns, on a highway which had quite heavy traffic and which was just about ready to fall in the stream. An emergency existed and we were short of money in the bridge fund, so in order to keep within the limit of our money, I decided to make an experimental job of repair and at the same time put the structure in a condition to accommodate the traffic.

The old bridge was composed of two outside steel arches tied together with two 12-in. cross beams which supported the floor. The whole structure was supported by vertical steel I-beams, backed with slabs of stone to hold back road embankment. The clear roadway on the old structure was 14 ft. and it was decided that it should be increased to 18 ft. This was accomplished by inserting three 15-in. beams running longitudinally and secured to floor beams, then on top of these 15-in. beams there was placed 5-in. I-beams each spaced 2 ft.-6 in. center to center. Each of these beams were 19 ft. long and of course they extended out over the trusses, but as they were all securely bolted to the beams on which they rested this small extension was not considered dangerous.

After the 5-in. beams were in place, corrugated metal arches curved to proper radius were inserted in each bay and the whole floor was then filled with concrete to a point 3 in. above the tops of beams. This concrete floor was then reinforced by 6-in. by 6-in. No. 6 steel wire mesh. On each side of said floor 6-in. curbs were turned up to a point 6 in. above floor and a 2½ in. galvanized iron guard rail inserted in each curb.

After this floor had properly set up, it was then thoroughly waterproofed by swabbing on three coats of hot pitch, on the final coat of which there was spread a layer of sand.

The contract price for this bridge was $2,371 of which price the greater portion was for concrete abutments and wing walls. The contractor's proposal was a lump sum, so the exact cost of the floor including all new steel work could not be determined, but from what calculation I have made, the price of the floor did not exceed $6.50 per square yard.

A recent examination of the structure which has been in use for four years reveals that it is in excellent condition and will give many years of service to the public.

This old bridge which was practically worthless, was rebuilt into a useful structure for the sum of $2,371; this amount represented a saving of approximately $2,500 for the county as a former estimate for a new bridge was $4,800.

Creosoted Slab Floor.—Another type of floor material which has been used to some extent in Wabash County in the last three years is a creosoted slab, made up of six pieces of 2-in. by 4-in. oak lumber. The 2-in. by 4-in. are fastened one to another by means of bolts which run through the six pieces of oak, in holes drilled for the purpose. These bolts hold the 2-in. by 4-in. together forming a compact unit 12 in. in width by 4 in. thick. Each of these units when laid in place is fastened to the adjoining ones by steel pins which hold the floor in place. The sub-floor structure is first placed in proper condition and on top of the steel or wood stringers are laid 2-in. by 6-in. pine nailers. These nailers are not secured to the I-beams but the slabs are spiked to them thereby strengthening and holding said slabs in place. After they are in place a 3-in. by 6-in. creosoted plank is spiked to each outside edge of the floor holding slabs in line and further securing them.

Slabs are of first class oak impregnated to refusal with creosote.

These floors have been laid only by the county road maintainance department, no contracts having been awarded for this type, but the material is making a first class floor and is, readily handled and laid in place, no skilled labor being required. The cost per square yard for this type of floor including sub-floor is approximately $10.50.

Another type of floor which has proven to be a success in our county and which is used on bridges under 36 ft. span is made up of small concrete arches supported by steel I-beams spaced about 2 in.-4 in. center to center and supported by abutments. Forms for these arches are made of corrugated galvanized iron of about 20 gauge curved to the proper radius. These forms are then inserted between the beams and are held in place by the lower flanges of beams. Concrete is then poured in each space between beams to a point about 2 or 3 in. above the top flanges. Surface of the floor is then water proofed, sanded and made ready for traffic.

The steel beams in the floor are secured against spreading by the placing of 1-in. bars which are spaced about 6 ft. apart and run across beams and hooked on ends both on top and bottom flanges. Several of these floors were constructed a few years ago over large dredge ditches with the idea in mind that if necessary the floor could be easily removed in order that dredges could pass through, after which steel could be replaced on abutments and the floor rebuilt.

In conclusion I wish to again emphasize the fact that it is poor policy to neglect bridge floors or any other part of a bridge for that matter.

A bridge is not any different than any other structure or building which is subjected to the damaging actions of the elements and other destructive factors which are constantly attacking them, and to erect such structures and then disregard them until they fall to pieces is to my notion, a mighty poor way for public officials to serve the taxpayers.

Acknowledgment.—The above is a paper presented Jan. 22 at the 15th Annual Purdue Road School.

High-Production Paving Job Shows Careful Planning

Ingenious Methods Applied on Illinois Highway Project

CAREFUL scheduling of operations and a close check on the relative efficiencies of various methods, together with the use of modern paving equipment and the application of several novel devices characterized the exceptional performance last year of the McMahan Construction Co. of Rochester, Ind., on Route 121, State of Illinois. The McMahan Construction Co. was awarded the contract for construction—including paving, grading, and culvert work—of three sections of highway totaling approximately 20 miles in length on Route 121, traversing Piatt, Moultrie, and Douglas Counties, on Sept. 22, 1927. The same contractors were awarded approximately two miles of county work adjoining, to be constructed under the same specifications as the state highway.

Pour 22 Miles in Five Months.—Grading and culvert work was begun on Oct. 10, following the letting, but the early approach of winter caused operations to be suspended about Nov. 25. The following spring the grading and culvert forces resumed work as early as the weather would permit, and the Koehring 27-E paver was started pouring concrete on April 11.

The weather following this date being favorable, progress was most satisfactory. In several weeks during the progress of the work daily averages of from 1,300 to 1,400 lin. ft. of pavement were made. During the record week, from July 12 to 18, inclusive, 8,501 lin. ft. of 18-ft. Illinois standard section pavement were laid. The biggest day's run was 1,815 lin. ft., poured on May 8. The entire 22 miles of pavement were poured by Sept. 23, or in less than five months from the date of starting, good and bad weather included.

Upon completion of this stretch of pavement, the paving outfit was loaded and shipped to another contract on Route 47 in Ford County, near Strawn, Ill., where five more miles were added to the year's production record, making in all a total of 27 miles with the one paver in one season.

Materials Handled Efficiently.—Power-driven equipment was used throughout the job, no teams being employed—with the exception of two, which were used to haul forms forward each morning. Transportation of all material to the mixer was accomplished by a 5-mile industrial railway, over which operated five 10-car trains. Each car hauled two 6-bag batches of coarse and fine aggregate, proportioned at the loading plant and ready to load into the skip upon arrival at the mixer. Enough cement, loaded on flat cars, was hauled with each trainload to supply the aggregate on that particular train. The trains were pulled by 7-ton Plymouth locomotives. The contractors experimented with the number of trains operated, trying both a 4-train and a 5-train schedule. It was found better to have five trains on duty with a material train always in waiting at the mixer than to use four trains and have the mixer occasionally wait for material.

Fig. 1.—Preparing to Unload a Batch of Aggregate from the Waiting Trainload. Notice the Two Blocks Bolted to the Under Side of the Skip. Placing Sacks at the Sides of the Subgrade Allows the Paver to Advance Without Giving Notice to the Cement Handlers

Aggregates were loaded into the cars at the plant with the aid of Brownhoist cranes and Johnson bins. The operators were prepared and waiting to pull the levers upon the arrival of an empty train, and a complete train was frequently loaded in four minutes. Cement was loaded on flat cars at the plant direct from the car by four men. A platform, 4 ft. wide and 20 ft. long, built on the floor level of the box cars in which cement was delivered to the plant, was used to stack enough cement for loading the next empty train.

At the mixer, one hoist operator and three men assisting him handled the batches of aggregate from the cars to the skip. Two men on the subgrade ahead of the paver unloaded and placed cement, while two more men dumped the bags into the skip. One man cut all cement bags and unloaded the empties on each returning train. It will be noticed in the illustration, Fig. 1, that cement bags were set up in straight rows along each side of the subgrade next to the forms. This method was found to be an improvement over placing the bags in the center of the subgrade, as it allowed the paver to move forward without interruption or notice to the cement handlers. Two flat-car loads of cement were kept at the mixer overnight and unloaded on the subgrade the first thing every morning.

Steel, Forms, Set in Advance.—A Monarch "50" tractor was employed for scarifying and grading ahead on the subgrade. A 5-ton Holt pulled fresnoes and Hug subgraders. This outfit was followed by a 5-ton Huber roller. The use of 4,000 lin. ft. of 9-in. Blaw-Knox steel forms on each side of the subgrade made it possible to keep approximately two days' completed subgrade ahead of the mixer at all times.

Center steel was staked in place as much as 1,500 ft. ahead of the paver. To prevent damaging this steel with the skip of the paver, the superintendent on the job devised the scheme of bolting two 10x10-in. wooden blocks to the bottom of the skip—one on each side of the subgrade. Placing the center steel ahead of the mixer in this manner is advantageous in that it allows a firmer job of staking the steel,

makes possible a straighter line for the center crack, and keeps the steel setter out of the way of the congested operations adjacent to the mixer.

Forms Oiled in Novel Manner.—Fig. 2 illustrates a novel adaptation of a common tool to concrete form work. This is nothing more or less than a 2-gal. pressure insect sprayer, complete with rubber hose and spraying nozzle. This proved to be a saver of oil as well as time. It was also found a useful piece of equipment for the night man to use in oiling the discharge bucket of the paver, the finishing machine, belts, floats, etc., to prevent concrete from sticking. The sprayer is equipped with a shoulder strap.

Surfacing with Rubber Hose.—Two puddlers and one spader were used ahead of an Ord finishing machine. Although it was traveling at a high rate of speed from start to finish, not a single instance was recorded where the paver was delayed on account of the finishing machine. An ingenious device used for surfacing the pavement following the finisher is shown in Fig. 3. This consists of a ¾-in. rubber steam hose, 22 ft. in length, fastened at each end to a 10-ft. round handle. This is operated by two men, standing about 20 ft. apart, on the same side of the pavement. The hose is swung onto the pavement just a little past the center, and pulled gently toward the edge, the hose ends of the handles being kept as close as possible to the concrete. In this way the laitance which has formed on the surface of the concrete is wasted over the forms without the slightest disturbance to the smooth surface of the pavement.

Grading, Shoulders, Etc.—Grading on the 22-mile project involved 165,000 yd. of excavation. This volume was moved with two complete Western elevating grader outfits, each equipped with ten 1½-yd. Western dump wagons.

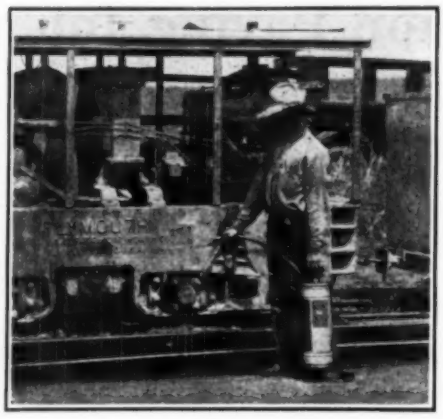


Fig. 2.—The 2-Gal. Pressure Insect Sprayer Used for Oiling Forms

One outfit was pulled by a Caterpillar "60" tractor and the other by a Monarch "75." The 11-ft. shoulders specified were completed by a 12-ft. Adams leaning wheel grader, followed by a string gang.

Old Macadam Base on Gravel Successful as Road Foundation in Massachusetts

Satisfaction with old macadam base over a gravelly subgrade as a foundation for modern bituminous macadam roads was expressed by R. W. Coburn, construction engineer of the Massachusetts State Highway Department, at the recent annual meeting of the New Hampshire Good Roads Association held at Concord. Massachusetts operates many miles of bituminous macadam roads, most of these being subjected to heavy passenger-vehicle and truck traffic. A review of the 1927 traffic census conducted by the highway department showed that at the points where travel was counted on the 15 heaviest traveled state roads in Massachusetts, the foundation under the pavement was in each case gravel.

Mr. Coburn cited a 5-mile section of the old Boston Post road, in support of the merit of old macadam crusts serving as foundations for bituminous macadam. This section was originally laid as a state highway more than 25 years ago as a thin, water-bound macadam surface over an old crust that had been compacted by a century of travel. In 1913 a 2-in. bituminous macadam top was added to the old crust, and today the surface appears as good and as smooth as when built. It is believed that the old macadam base, together with the gravelly nature of the underlying grade, are responsible for the present excellent condition of this road surface.

This is only one instance, Mr. Coburn points out, of the reliability of old macadam base over gravel subsoil as a foundation for a roadway surface carrying modern heavy traffic. There are many miles, he states, of heavily traveled bituminous roads that have no other foundation than a macadam base over a natural subsoil or gravel foundation. Such confidence has Massachusetts in the old road crust as base, that its disturbance and subsequent replacement with stone fill is not counseled.

That confidence in gravel foundations is not misplaced, is shown by maintenance statistics kept by the highway department. These figures reveal that the surface maintenance cost of bituminous macadam asphalt roads from 1 to 10 years old, including patching of frost breaks and surface treatments, is only $124 per mile for roads constructed on a gravel foundation, whereas roads built over stone fill require an annual expenditure of $147.

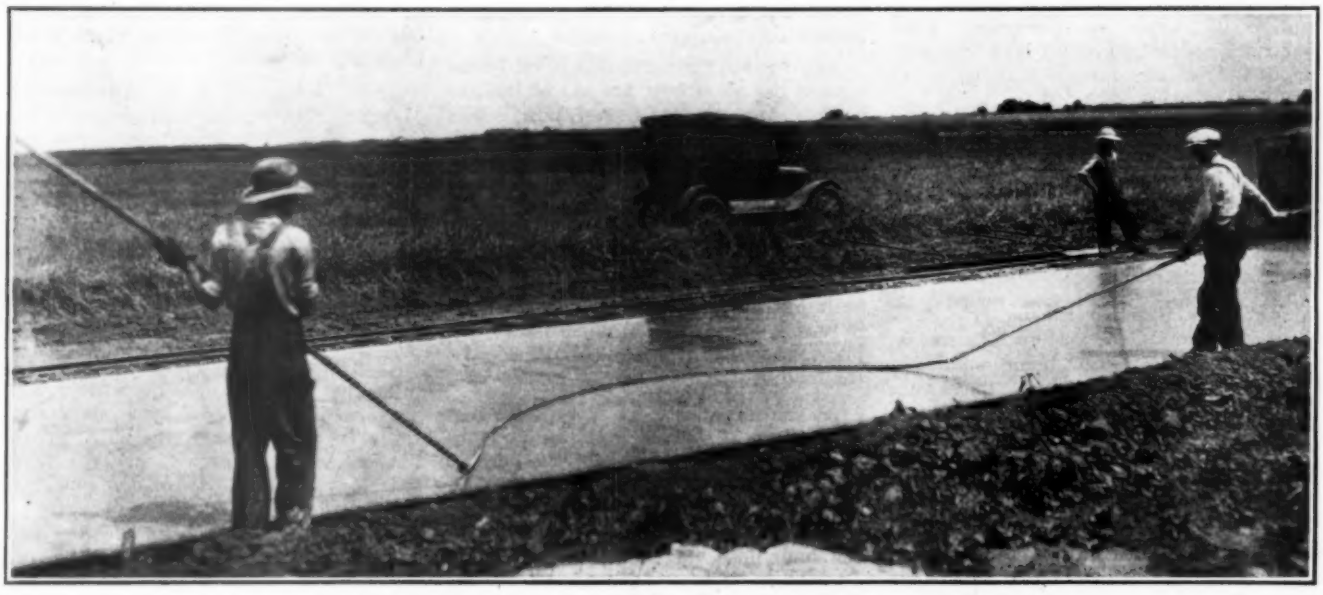


Fig. 3.—Surfacing the Pavement with a Length of Rubber Steam Hose

Important Considerations in Planning Detours

Useful Suggestions for Serving Traffic During Construction

By W. F. BAUMGARTNER

Division Engineer, Wisconsin Highway Commission, Eau Claire, Wis.

AS highway officials, we have seen and will continue to see, an ever changing mode of construction and maintenance. Our main object is, and always must be, a continuous improvement in construction and maintenance, so that in the end we are giving better highway service. If we, as state and county highway officials, do not operate our highways properly, someone else will soon be doing it for us. Every safeguard, every convenience, and every incentive for safe and efficient highway operation must be provided. We must keep our route markings, warning signs and our traffic control methods up to the demand of modern highway use. Highway efficiency is measured by the service being rendered. We must not forget that, regardless of whether or not we are maintaining our state and county trunk system satisfactorily, we must provide for suitable detours while the main roads are under construction.

Concrete Construction to Avoid Detours.—When we are considering jobs for which detours are necessary, we should consider the amount of money that there is available for the job. We find that in many instances in the past, a repetition of detours occurred year after year on the same road. Would it not be more advisable in many cases to defer construction until enough funds are secured to put in a larger job, thereby eliminating the year after year detour on the same road? We find in some instances that many small jobs are scattered about the county. It would be better to concentrate on larger jobs which would tend to eliminate the necessity of the same road being tied up year after year. This same reasoning should apply on our state problems, especially on the most important through roads. We believe that greater effort should be made to concentrate our work on certain highways each year, leaving some through highway free of construction and detours. Some attention has been given to this, but in looking over the highway service map during the summer season, we are led to believe that not enough planning and thought has been given to this matter. We therefore believe that more careful planning of construction work should be done, so that in the end there will be a complete correlation between construction and detours.

Detours and Real Service.—The detour should be planned by the Division Engineer, the county highway commissioner and his committee, as it is they who are planning for future construction. A construction job or a gang maintenance job should never be considered without first giving due thought as to how traffic is to be served while the particular job is being built.

The word "detour" even at its best, creates no pleasant reaction on the part of the average motorist. A detour is defined as meaning "a roundabout way," but a great many people, through imagination or experience, have established various definitions which are not entirely pleasing. In planning our detours, results should be sought that will bring the word back to its proper definition, and create the impression among the people that the detour is an indication of real service, that it is a safe and convenient route avoiding highways which are under construction and probably impassable. We should so plan our detours that when a traveler comes to a point where he must leave the main road, the information sign indicating the detour will not bring to his mind a mental picture of a road that would give him a nightmare. On the other hand, he should feel that he is merely leaving the regular highway for a time, the road being possibly a little longer in distance than the regular route, but nevertheless a very comfortable and safe highway to drive on.

Careful Planning Needed.—The planning of a detour should not be made in a hasty or haphazard manner, but considerable time should be taken to find a road which is the best suited to take care of the traffic during the time that the road is under construction. Seldom do we have jobs that come in unexpectedly. There are a few instances that have occurred but, as a rule, jobs are planned at least one year in advance, and oftentimes on the construction of the state trunk highway system, jobs are planned several years in advance. Therefore, with a little forethought, there is ample time in which to select the proper route and to put it in condition. For the past several years, in Division No. 6, the division office in cooperation with the county highway commissioners and their committees, have made a careful study of what we should do when a particular job is under construction. We made field inspections and decided on just what must be done to the road selected as a detour in order to put it in good condition for safe traveling; rough estimates were made, and then efforts were made to secure necessary funds to put the road into shape.

Important Considerations in Selecting Detour.—In selecting a road for the detour, several important points should be considered in determining the route, namely:

(1) The shortest possible route should be considered.
(2) Safety of the route.
(3) Expenditures necessary to handle the required traffic.
(4) Future importance of the road selected as a detour.

We believe that distance is the most important factor, especially on heavily traveled highways, and this should be considered in choosing the route. The loss of time and increased mileage, if computed on a heavily traveled highway, would soon reach astonishing sums.

Safety of highways is considered essential. Therefore, we must consider the type of surfacing, width of roadway, alignment, and grades to determine whether the road should be considered adequate. Any route chosen should be safe. The roadway must be wide enough to accommodate the traffic, and where busses and trucks are a common vehicle, we must give this our special attention in order to avoid serious accidents. Poor grades and alignment are sources of constant danger and serious inconveniences. The surfacing should be of some all-weather type suitable to the traffic requirements. If a gravel or similar surfacing material is to be depended upon to carry heavy traffic of all kinds, it is desirable to add some dust preventative in order to maintain the road in a serviceable condition at all times. The dust nuisance is probably greater on a detour than on our regular highways because of the fact that the road is strange to practically everyone and the driver depends entirely on his own vision and the guidance of signs to warn him of existing curves or hazards. The marking and signing of a detour, while only of a temporary nature, probably requires even more thought than that on our regular highways. A motorist on a strange road depends, to a great extent, on the signs for guidance and information, and the majority are strangers so far as the temporary routes are concerned. The marking should be complete and precise in order to avoid possible confusion and accidents.

Estimating Probable Cost.—Available funds are undoubtedly a great factor in determining the road to be used as a detour. Therefore, it is absolutely necessary to make an intelligent estimate of the probable cost of the detour.

Often it is necessary to use maintenance money for this purpose. We have also made this a direct charge against the project where adequate funds were available. In many instances, counties have made a direct tax levy for this purpose. But, regardless of how the job is financed, we must consider just how the work will be financed before it is started. This often requires several meetings between the county and the state highway officials. Probably the best method of financing the improvement of the detour is to use money set up for the project, as we believe that the charge is justified, and we also consider it a part of the construction job. Where adequate funds are available, we believe that the shortest possible detour should be selected. On the other hand, if funds are inadequate, it is our opinion that possibly a longer route should be selected. In spite of the fact that increased mileage is an additional expense to the public, it is admitted that the great majority of people would rather drive a few miles further over a safe and convenient route in preference to a shorter route where conditions are not satisfactory and could not be made satisfactory except through the expenditure of considerable money.

Where improvements of considerable cost are necessary in order to provide a suitable route, some effort should be made to locate the route where the greatest possible benefits will be derived from such expenditures, even after the detour is no longer used. In this connection, it would seem advisable to use state or county trunk highways for detours as far as possible, because any improvements made are not a loss when the detour is abandoned, but are a benefit to the road in question.

Study Necessary Improvements.—After having selected the best route for the detour, a careful study should be made as to the required improvements necessary. The work necessary to be done upon this road should be made preferably a year in advance of the construction of the project, but in no case should work be done after the road selected is used as a detour.

Small jobs, such as a short piece of construction or a bridge, are often overlooked or are not given enough consideration. We very often run into bad layouts in instances where we expected just a short job, and due to weather conditions or some other unavoidable circumstances, the job drags along and results in no road and no detour. In some sections of the state we have counties that have a large mileage of road that, due to the topography of the locality, scarcity of surfacing material and other factors that go to make road construction costly, we find very few of these roads improved. Under these conditions it is rather difficult to get enough money to place on a detour. In a case of this kind, there is only one thing we can do, and that is to plan our work so that the detour will get into the best maintenance possible.

There are many important county trunk highways in the state where the traffic is considered heavy. We believe that the counties should plan the detours for these highways just as carefully as those on the state trunk system. Good detours properly marked should be provided by the counties whenever the important county trunks are under construction and wherever it is necessary to keep traffic away from the construction.

We find that cities and villages are very careless about notifying either the county or the division offices when construction is starting which requires a detour. In many cases we have encountered barricades across a street which is being used as a state or county trunk. Usually no signs were present to indicate where traffic was to go, and when there were signs, there appeared only the word "detour." The motorist evidently was supposed to know how to travel around the work in order not to encounter the barricade. We believe that all cities and villages should be requested to notify either the county highway commissioner or the division office when such work is being contemplated, so that proper signs can be provided, and the detour may be at least properly marked, thus avoiding unnecessary confusion on the part of the motorist.

Marking and Signing Detours.—The marking and signing of a detour involving the state trunk system is handled by the division marking and signing department. It is absolutely necessary that after the route is selected for a detour, a sign survey should be made to determine the requirements of the road. Signs should then be made up and placed in store so that when the time arrives they will be ready and can be put up; they should be erected several days before the detour becomes necessary. It is best to erect all the signs on the detour, but to leave the ends unmarked. These end signs can then be placed on the day that the detour becomes necessary and can be erected by the inspector or the contractor. We believe that it is advisable for all counties to have a supply of standard detour signs on hand, because there are many instances where unforeseen detours are necessary, and we have often found that the road selected for a detour was either unmarked, or inadequately marked. This latter condition applies usually to gang maintenance jobs. Whenever it becomes advisable or necessary to change the route of the detour on account of various reasons, such as shortening of length, etc., the division office should be notified so that the marking and signing can be taken care of by the division organization. We must remember that in all cases our detours must be adequately marked and signed.

Maintenance of Detours.—When the detour is in use, we must give it the proper maintenance. Adequate maintenance equipment should be used. Above all, do not rely upon some farmer living upon the detour for its proper maintenance. The best equipment and proper maintenance methods are none too good for the detour. When detouring over town roads, we should try to leave them in good condition and not discontinue their maintenance before the detour is removed, thus leaving them in poor condition. This act tends to create a bad feeling in the locality which should be avoided by all means. The detour should be well maintained until the new road is opened for traffic. If it is not, then we are falling down on our maintenance and are not serving the traveling public. Another pertinent fact that we must keep in mind, and one that should keep us up and going to maintain these detours in good condition, is the fact that a traveler making a trip through the state, perhaps traveling over good detours, should happen to encounter a detour that was in poor condition, he would forget all about the good detours and be unfavorably impressed with the one that was not properly maintained. This is one reason why detours are looked at unfavorably, and we trust that better maintenance and uniformity in this connection will be secured throughout the state.

As you all know, the commission sends out a weekly service map showing the construction and detours necessary due to construction during the working season. The division offices must furnish this information to the Madison office weekly. It is not possible for someone from the division office to visit all the construction jobs the day prior to sending this information in to Madison. May we ask that you county highway commissioners cooperate with us to secure authentic and up-to-the-minute information on the condition of the detour where a detour is necessary, and on the construction job where traffic is being taken through? A little assistance from you along this line is requested so that when the service map comes out the latter part of the week, it will be correct, and will therefore be of more value to the traveling public.

Summary.—The planning of a detour can be briefly summed up as follows: To make our plans well in advance of all jobs so that we will get the following results:

A safe road, a road that will carry the traffic at all times and under all conditions; to have the shortest possible route, keeping in mind the factors of safety and surface conditions; to have a well marked and well maintained road from the time the detour is put into effect until it has been removed; not to overlook the small jobs that may require a detour or by-pass, and to so plan our work that some of the detours can be eliminated. We should

plan our construction jobs so that the same job or road will not have to be detoured for two seasons.

Therefore, if we plan our detours well and execute these plans to the last detail, we will then be giving the public the service that they are entitled to, and the word "detour" will mean that we are only leaving the main highway for a short time, and that the road used is as good as or better than the old road.

Acknowledgment.—The above paper was presented at the 18th annual Road School of the Wisconsin Highway Commission.

Unit Prices on Missouri Road Work

The recently issued 6th biennial report of the state highway commission of Missouri, for the period ended Dec. 1, 1928, contains the following comparison of unit prices on contracts awarded. A few explanations may add to an understanding of the tabulation. The highest price for each item occurs invariably in contracts not representative of the whole. For instance, an isolated project may be so located that materials and labor are difficult to obtain, transportation costs increased by long hauls, or construction processes unusually difficult, while at the same time the quantities of work items in the contract remain small. Inversely the lowest prices are obtained in large contracts where competition of bidders was keenest and working conditions most favorable, or in some instances they represent the bid of an ill-advised contractor who suffers financial difficulties accordingly. The report states that in general the 1927 and 1928 prices have been quite satisfactory, permitting of approved workmanship and a fair margin of profit to the contractor.

Earth excavation and concrete pavement prices for 1928 representing a large percentage of all construction costs are the lowest in the history of the department. This, according to the report, is believed to be a reflection of improved methods and increased efficiency of contractor's forces, improved machinery, state furnishing of materials with selected routing of shipments, well organized supervision through the bureau of construction, and is the natural result of all the developments in highway construction.

Comparison of Unit Prices on Contracts Awarded

Item	Unit	High 1928	Low 1928	Averages 1928	Averages 1927
Clearing and grubbing	Station	$30.000	$ 3.000	$17.810	$19.075
Hedge pulling	Station	30.000	5.000	12.674	14.641
Linear grading	Station	10.000	1.000	5.243	8.013
Class "A" excavation	Cu. yd.	.750	.175	.339	.371
Class "B" excavation	Cu. yd.	1.000	.400	.679	.706
Class "C" excavation	Cu. yd.	4.000	.750	1.420	1.559
Borrow excavating	Cu. yd.	.600	.150	.305	.344
Overhaul	Sta. yd.	.080	.019	.041	.044
Rolling Emb	Day	25.000	25.000	25.000	27.220
Jetting fills	Cu. yd.	.150	.030	.075	.137
Gravel pavement	Cu. yd.				
Gravel pavement	Sq. yd.	4.000	.530	1.843	1.739
Gravel stockpile	Cu. yd.	3.750	.500	1.616	1.732
Chat pavement	Cu. yd.	2.450	.750	2.023	2.442
Chat stockpile	Cu. yd.	2.450	.600	1.985	2.415
*Concrete pavement	Sy yd.	2.763	1.613	2.023	2.233
Bridge approach slabs	Sq. yd.				3.456
Reinf. for approach slabs	Pound				.058
Conc. base course	Sq. yd.				1.500
Sledged stone base	Sq. yd.				3.500
Asphalt pavement	Sq. yd.	1.180	1.180	1.180	1.630
Vitrified brick course	Sq. yd.				1.000
Barricades	Each	50.000	5.000	33.488	37.040
Reloc. barricades	Each	25.000	5.000	15.146	15.695
Detour signboards	Each				30.000
6-in. V. C. underdrains	Lin. ft.	1.000	2.000	.460	.500
15-in. R. C. pipe	Lin. ft.	2.750	1.250	2.441	2.632
18-in. R. C. Pipe	Lin. ft.	3.500	2.500	2.881	3.154
24-in. R. C. pipe	Lin. ft.	4.500	3.000	4.000	4.481
30-in. R. C. pipe	Lin. ft.	5.000	4.000	4.500	6.000
36-in. R. C. pipe	Lin. ft.	4.500	4.500	4.500	
15-in. V. C. pipe	Lin. ft.	3.250	1.500	2.395	1.911
18-in. V. C. pipe	Lin. ft.	3.600	1.850	2.811	2.514
24-in. V .C. pipe	Lin. ft.	4.000	3.000	3.750	3.438
30-in. V. C. pipe	Lin. ft.	4.900	4.900	4.900	5.500
15-in. C. M. pipe	Lin. ft.	2.750	1.730	2.062	2.009
18-in. C. M. pipe	Lin. ft.	3.000	2.000	2.479	2.359
24-in. C. M. pipe	Lin. ft.	4.000	2.800	3.241	3.451
30-in. C. M. pipe	Lin. ft.	5.000	4.500	4.833	3.566
Relaid pipe	Lin. ft.	2.000	.500	1.018	1.388
Conc. curb	Lin. ft.				1.000
Conc. gutter	Lin. ft.				.981
Conc. curb and gutter	Lin. ft.	1.250	.500	.804	.820
R. O. W. markers	Each	3.480	.350	1.092	.900
Timber ditch checks	Each	15.000	7.260	9.452	17.100
Stone ditch checks	Each	10.000	4.000	5.818	
Guard fence	Lin. ft.	.900	.640	.746	
Plain rip rap	Sq. yd.	5.000	.750	2.383	2.171
Grouted rip rap	Sq. yd.	6.000	2.480	3.499	2.813
Class "A" concrete	Cu. yd.	50.000	21.000	41.144	39.448
Class "B" concrete	Cu. yd.	30.000	12.000	18.223	18.585
Class "C" concrete	Cu. yd.				16.800
Class "X" concrete	Cu. yd.	29.700	12.400	16.655	16.869
Reinf. steel	Pound	.070	.044	.054	.055
Bridge excavation	Cu. yd.				2.750
Tim. piles in place	Lin. ft.	1.000	.750	.870	.963
Tim. pile cut-offs	Lin. ft.	1.170	.500	.957	.805
Creo. piles in place	Lin. ft.	1.750	.750	1.181	1.281
Creo. pile cut-offs	Lin. ft.	1.300	.990	1.126	1.138
Creo. timber	F. B. M.	.120	.100	.110	.117
Fab. Struc. Steel	Pound	.120	.050	.073	.065
Steel castings	Pound	.150	.100	.138	.139
Gas pipe Br. rail	Lin. ft.	.850	.450	.523	.475

*To the Unit Bid Prices has been added the cost of state furnished materials. The price per sq. yd. represented being the total unit cost.

The High Toll of Traffic

As an indication of the cost of inadequate traffic laws, in human life, A. B. Barber, manager of the Transportation Department of the Chamber of Commerce of the United States, draws a parallel for three groups of states, showing the increase in the number of fatalities compared with the increase in registration, between 1920 and 1926. They are:

North Atlantic States (Maine to Maryland inclusive):
- Increase in fatalities.... 64 per cent
- Increase in automobile registrations .....158 per cent

Middle Western States (Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Missouri, Kansas and Nebraska):
- Increase in fatalities....100 per cent
- Increase in automobile registrations .....126 per cent

Southern States (Virginia, North and South Carolina, Kentucky, Tennessee, Mississippi and Louisiana):
- Increase in fatalities....230 per cent
- Increase in automobile registrations .....194 per cent

"The states in the second and third groups," Colonel Barber adds, "had until the last year or two, and most of them still have, very inadequate motor vehicle laws and incomplete administrative organizations."

Three Large Highway Spans Under Construction in Pennsylvania

Three important bridge constructions were placed under contract during 1928 by the Pennsylvania Department of Highways.

The largest structure is to span the Allegheny River on Route 211 in McKean County. It will have an over-all length of 450 ft., not including a ramp, which will be 207 ft. in length.

The longest steel span designed by the bridge unit was for a combination steel and concrete structure which will carry State Highway Route 5, Luzerne County, over the tracks of the Delaware & Hudson and Lehigh Valley Railroads at Dupont. The bridge will have an over-all length of 362 ft., a roadway width of 30 ft., and one 5-ft. sidewalk. The main span of this structure will be a 105-ft. steel truss span.

One 3-span concrete arch bridge was built on State Highway Route 66, Armstrong County, with an over-all length of 302 ft.

Highway Maintenance in the Province of Ontario, Canada

Methods for Earth, Gravel, Macadam Bituminous and Concrete Roads

By R. M. SMITH
Deputy Minister, Ontario Department of Highways

WE MUST protect and conserve every cubic yard of road material that we have at our disposal. Deposits which appeared to contain unlimited quantities, when provincial construction was first started in 1918, have now been worked out or abandoned, and it is regrettable that the major portions of these deposits have been blown from the highways into the fields. An unprotected gravel road, carrying an average traffic of 2,000 vehicles per day the year round, will lose at least 1,000 cu. yds. of gravel per year—a great loss with no possibility of replacement.

What applies to gravel applies to water bound macadam or any type of road where the surface is not protected. Many of us have passed over macadam roads, well built in the first place, which have become pitted and full of holes because of lack of surface treatment. Unfortunately many municipalities take the stand that once the road has been built, their responsibility ends.

It is the practice in the province of Ontario to commence a maintenance crew just as soon as construction work has been completed. Originally, it was customary to depend upon the contractors to maintain the road surface they had laid for a period of years, according to the time specified in the contract, but considerable difficulty was found, first, in determining when the road was out of repair and, second, in convincing the contractor that such was the case. As the department of highways supplies the major portion of the ingredients that enter into any pavement, it is felt that, with proper inspection at the time of construction, there should be no failure, and provided there is a failure, the department should assume responsibility. The consequence of this conclusion has been that on our paving contracts no maintenance bond is required. It is believed that this practice is to be commended. In the first place, our roads are kept in a much better state of repair and, secondly, failures are very rare. Ontario, it is believed, has a system of highways of which the province can be justly proud. They are maintained to a standard as high as that of any other province in the dominion, and equal to that of any of the states to the south of us.

Maintenance applies to all roads, from the more permanent asphalt or concrete surface to the clay or gumbo road.

Earth Road Maintenance.—It would possibly be of interest to start at the beginning, discussing first the ordinary dirt road, a kind of road of which Ontario has only a very small amount. The greater portion of the mileage in the western provinces, however, is of this type. Various methods of maintenance have been tried by officials in charge of the work, and some have proved successful, while in other cases the treatment is still in the experimental stage, another year being required to determine the outcome. The general practice is to use the ordinary steel drag or planer, mechanical or horse drawn, operating frequently enough over the dirt road to prevent the forming of ruts or holes.

Saskatchewan Experiments in Oiling Gumbo Roads.—This year the province of Saskatchewan, under the direction of H. R. MacKenzie, Chief Field Engineer, is experimenting with an asphaltic road oil. From the information available it appears that the gumbo road is subjected to two surface treatments, each of ½-gal. to the square yard of road surface, sufficient time being allowed to elapse between the first and second treatments for the first application to become dry. Following these treatments, approximately 580 cu. yd. of gravel per mile are applied. As the road under consideration is approximately 16 ft. in width, this allows about 2 in. of gravel over the entire surface. Provision is also made at the time of handling the work to apply 1/3 gal. of oil the following year, with an additional coating of 250 cu. yd. of gravel per mile. Throughout the entire process of graveling the mechanical drag or grader is kept in motion so that even consolidation may be secured. This will also apply during treatment the following year.

The object in treating the gumbo road prior to the application of the gravel is to provide a mat which will be sufficiently supporting so that it will prevent the gravel from sinking into the subgrade.

As regards the construction of this type of surface, it is evident that its value will only be proven after one or two years' traffic. The cost of the work is estimated by Mr. MacKenzie at about $4,000 per mile. Providing this treatment is successful, it may be a real solution for many miles of medium traveled western gumbo roads.

Gravel Road Maintenance.—Next in importance comes the gravel road—not the gravel surface we knew 10 years ago, consisting of material heaped in the center of the road, but the smooth, wide and flat crowned road with its beautiful riding qualities, discomforting only because of its dust nuisance. The highest type of construction in semi-permanent surfaces cannot compare from the motor car driver's point of view with a properly and well maintained gravel road.

In highway construction and maintenance no type of surface provides for greater flexibility in method of preservation than the surface of a gravel road. Every patrolman, highway official or engineer has an opinion of his own. In Ontario three distinct methods have been evolved. First, the use of the steel drag; second, bituminous surface treatment; and third, light oil or chemical treatment.

In the first method the steel drag or maintainer drawn by horses or power tractor is used. To prevent holes, this equipment is passed over the road as frequently as is considered necessary, dependent upon weather conditions, the class of gravel used, and the traffic the road is obliged to carry, the most effective work being done during or following wet weather. This method is recommended where materials are plentiful and traffic light.

Bituminous Treatment, Surface and Mulch Methods.—The second mentioned, that of bituminous treatment, is comparatively new in Ontario. It has much to be said in its favor, however. The dust nuisance is eliminated, material conserved and a driving surface provided equaling the ordinary gravel road without its inconveniences. Two methods of treatment have been tried, one known as ordinary surface treatment and the other as the mulch method. In the first case the bituminous material is sprayed over the surface, sufficient gravel being applied following this to provide a cover and keep the tar or asphalt from picking up. The mulch method, which is the one more frequently used in Ontario, has been designed with a view to providing a mat on the gravel road sufficiently thick to ensure that all loose stone up to 1½ in. in diameter are covered and cemented into position.

The method of procedure is as follows: Apply sufficient suitable gravel to the road to provide when compacted a depth from 1½ to 1¾ in. Treat the surface with bituminous material. Either Tarvia-B or 60 per cent asphaltic road oil can be used. Windrow the treated float to one side, treat the base, and the loose treated material can then be spread evenly over the road, being continually agitated until surface has set up under traffic. The total application of bituminous material amounts to approximately ½ gal. per square yard, the cost on a 20-ft. road running in the neighborhood of $2,500 per mile. If in the following spring the surface of the road is pitted to an extent greater than 25 per cent, a scarifier is used to loosen all materials to a depth of approximately 2 in. The bituminous cemented lumps are finely broken and ¼ gal. of bituminous material applied, followed by a light application of gravel to prevent picking up.

Road Oils and Calcium Chloride Treatment.—Where it is intended that a permanent type of surface will be constructed in the near future, a temporary treatment using light road oils or calcium chloride is considered. These methods of treatment are fairly cheap, costing approximately $300 to $400 per mile. They provide a dustless surface, thereby conserving material and increasing safety in driving.

In the case of asphaltic road oil, care must be exercised in its application so that a mat will not be developed. Anywhere from 1/7 to ¼ gal. of material is applied per square yard, dependent upon the kind of gravel in the surface. Almost any class of gravel road will accept this type of treatment, giving fair results.

As an alternative to asphaltic road oils, flake calcium chloride may be used. Its application is very simple, being a matter of spreading the chemical over the road at the rate of approximately 1½ lb. to the square yard. This quantity is sufficient to keep the road in moist condition for about ten weeks under ordinary summer traffic.

Calcium Chloride Water Experiment.—In addition to the flake material, the department this year has been experimenting with calcium chloride water, a product of a well sunk at Concord, Ont. This solution has something to recommend it, in that its application can be effected very quickly and under almost any weather condition. Last year the material was tried over several miles of our provincial system with fairly satisfactory results. The cost is in the neighborhood of $200 per mile. The material is applied by the ordinary pressure distributor, similar to the equipment used in the application of tars or asphalt. However, a decision as to the merits of this material should be delayed until the road has passed through the severe weather conditions of winter and spring.

Macadam Road Maintenance.—The maintenance of macadam road surfaces possibly gives rise to more criticism than any other class of work we do in connection with the provincial highways. Tar or asphalt are used. Their characteristics, high cementing value, dust laying properties and waterproofing qualities, make them invaluable as a means of providing a protective coat.

While it may appear from the casual observer's point of view that the treatment of this type of road is a fairly simple matter, it has been found that it is quite possible to spoil a good macadam road by inexperience on the part of the operator doing the work. For instance, the application of too great a quantity of bituminous material necessitates more sand or stone being applied to prevent picking up, thus developing a mat which will shove and eventually make the road very wavy and uneven. We have tried in our work to curtail our treatments to such an extent that only a thin film of bituminous material will be applied to the surface, in this way maintaining the even contour of the original construction.

Surface Treatment on Half Road Sections.—In our specification, developed during 1928, we have provided as a convenience to motorists that our surface treating will be carried out in two distinct applications: one during the months of May or June, treating half the road, the second treatment providing for the opposite side being done in October. This has provided a driving surface at least 10 ft. in width free from newly applied bituminous material at all times during the season. While this has slightly increased the cost, it is believed that the additional expenditure can be justified when we keep in mind the damage to the motor car caused by the splashing of bituminous materials.

Maintenance of macadam roads does not involve surface treatment alone. This type of road is liable to break up during the severe frost conditions in the spring, with the consequence that a considerable portion of the old road becomes so badly affected that it must be replaced. Where this is necessary, we remove the old section, re-building it with an aggregate similar to that used in the adjoining sections, the surface inch of the patch frequently being of the premix type. The practice is to put the entire surface of the road in first-class condition before surface treating is done.

The Ontario provincial system at the present time has well over 400 miles of macadam surface laid prior to 1923 and still in very satisfactory condition. Treatment of macadam surface generally occurs every two years.

While discussing the treatment of macadam roads, it is possibly of importance to consider the various classes of material that have been used in surface treatment. We have in Ontario varied treatments between what is known as 40 per cent asphaltic base material to 80 per cent asphaltic base, and from a Tarvia-B material to a Tarvia-A material. Our practice is to use lighter material in the initial treatment, believing that we secure much better penetration than if the heavier material is used. We have, however, in recent years found that the heavier materials properly heated will provide a more satisfactory final surface and will not pick up so readily. Engineers at the present time are inclined to recommend the heavier class of materials rather than the use of the lighter grades. Following the application of bituminous materials, from 15 to 20 lb. of ⅜ to ⅝-in. crushed stone per square yard are applied to the surface, a coarse sand frequently being applied as well if conditions warrant.

Maintenance of Bituminous Penetration Roads.—Practically the same methods as used in the surface treatment of macadam roads apply in the process of treating a penetration road, with the exception that even greater care must be exercised.

To appreciate the difficulties, one must understand the construction of this type of road. As the name indicates, the road is built by pouring the hot bitumen into the interstices of the loosely compacted stone, after which the surface is consolidated by rolling. Unfortunately, however, the bitumen must of necessity have a low melting point, with the result that the surface frequently bleeds. Officials in charge of the maintenance of this type of road must anticipate the amount of bleeding that will occur. Too heavy a treatment will produce a slippery road, dangerous under ordinary conditions, but extremely so during wet weather.

Maintenance of Concrete Roads.—As maintenance is required on other types of roads, so it is on concrete. It is to be regretted that the phrase "permanent surface" is taken much too literally by most municipalities. The concrete surface will contract, with the result that cracks form and these must be filled. Many contraction joint fillers are made which have proven satisfactory and have been used successfully. The main thing is to use the filler in time. Our practice is to use any good bitumen base filler, treating the cracks both spring and fall. The actual operation is carried out by a small gang of men equipped with sand truck, tar kettle and pouring apparatus. The cracks are thoroughly cleaned either by wire brush or compressed air, after which they are filled with bitumen, immediately followed by the application of sand to prevent picking up.

In addition to the work of filling cracks, we often find it necessary to make more extensive repairs on concrete roads. Where there are of a minor nature, covering small areas, we generally use a pre-mixed bituminous aggregate of some kind. Where it is necessary to replace a section of the

concrete road one of the fast setting cements is used. Another alternative to this is the use of calcium chloride as an admixture. Either method may be applied satisfactorily if ordinary care is exercised. Our practice is to use a mix that will permit of the pavement accepting traffic within a period of from three to four days.

Asphalt Surface Repairs.—Asphalt road maintenance up to the present time has consisted almost entirely of replacements, asphaltic surfaces on macadam base and concrete being chiefly affected. It is the general practice in Ontario to let this work by contract on a square yardage basis. We believe that this method commends itself where construction is fairly recent and repairs of a minor nature. It should be kept in mind, however, at this point, that asphaltic surface was first laid on provincial highways in Ontario in 1920 and then only in short sections. Since then we have built 360 miles.

The major portion of our asphaltic road construction work has been done in the vicinity of the larger cities. This has also permitted of convenient and rapid maintenance, due to the fact that many municipalities are operating asphalt plants and they are always prepared to cooperate with us to the extent of supplying small quantities when required. In locations where these conditions exist, we purchase the mixed material by the ton, haul it to the job, apply and consolidate it, using a small gang of men working on a day labor basis.

The method used and accepted as good practice in this class of maintenance is as follows: First, remove the damaged or affected area, cutting sufficiently well back into the good surface so that the new patch will be consistent with the adjacent materials; second, paint with hot bitumen all edges coming in contact with new material; third, deposit and evenly spread hot asphaltic mix to such a depth that upon consolidation with the roller it will be just a trifle higher than the surrounding surface. Traffic will continue the consolidating process until the entire surface is at the same elevation.

Mixed Macadam.—During the last three years the department has been engaged in the construction of a type of asphaltic pavement which has been classified as mixed macadam. Its construction varies somewhat from the standard type generally accepted, first, in the ingredients used, and, second, in the method of application. The ingredients used are asphalt approximating 4.75 per cent, and crushed stone classified as crusher run, varying in size from dust to material passing a 2-in. ring. The method of application consists in transporting the hot mixed materials to the road, spreading by mechanical means and consolidating. The surface of this road, as might be expected, due to the percentage of coarse aggregate used, will be open. To seal and waterproof, a surface treatment is applied, sufficient chips being added to fill any voids that may exist.

As this type of pavement can be recommended for sections where detours are difficult to obtain or conditions require that a non-skid, comparatively cheap type of pavement shall be laid, its construction may be extensive.

The maintenance of this kind of surface, while consisting of minor repairs at the present time, may be fairly heavy at a future date. Surface treating, we anticipate, may be necessary and in this connection we are making a study of the use of emulsions, their use under wet or dry conditions being in their favor, not to mention rapid drying qualities which appeal to the motorist. This year a number of sections are receiving treatment and their success or failure will govern our future activities along this line.

Generally speaking, maintenance is the protection of the investment made in the construction of our highways. It is as essential as the protection which any business man would give to invested capital. Ontario has tried to keep this important item before our engineers at all times. While we appreciate that it is the practice in the United States to separate the responsibility for maintenance and construction, we have hesitated about doing so in Ontario, feeling that one department would be quick to take advantage of such a situation, blaming the other in case of failure. As to the correctness of our policy, it is left to the user of our highways to decide.

Acknowledgment.—The above paper was presented Feb. 15 at the annual meeting of the Engineering Institute of Canada.

House Grants Fund for Survey of Pan-American Highway

By unanimous consent, the House of Representatives approved a resolution by Representative Cole, of Iowa, providing for the cooperation of the United States with the other countries of the Pan-American Union in a study of the proposed Pan-American Highway, and a report to Congress on its feasibility and prospective route. The measure now goes to the Senate for confirmation.

If the Senate approves and the President concurs in this action, the Secretary of State will have at his disposal the sum of $50,000 to be expended in cooperation with the governments of Central and South America in the first field study of this international project that for decades has engaged the attention and fired the imagination of the political and economic leaders of the several countries affected.

To Study Curing of Concrete Pavements

The Executive Committee of the Highway Research Board, National Research Council, on Feb. 15, announced the formation of a special committee to conduct an investigation of the problem of proper curing methods for concrete pavements. The work will consist largely in correlation of the research work being carried on by the Bureau of Public Roads and various State Highway Departments. The committee consists of the following:

Chairman, F. C. Lang, University of Minnesota and Minnesota State Highway Department; E. F. Kelley, Chief of the Division of Tests, U. S. Bureau of Public Roads, Washington, D. C.; W. A. Slater, Research Professor of Engineering Materials and Director, Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa.; F. V. Reagel, Engineer of Materials and Tests, Missouri State Highway Department, Jefferson City, Mo.; Frederick E. Schnepfe, Civil Engineer, Washington, D. C., H. F. Conner man, Manager, Research Laboratory, Portland Cement Association, Chicago, Ill.; Stanton Walker, Director of Engineering and Research Division, National Sand and Gravel Association, Washington, D. C.

The work of investigation will be carried on by Fred Burggraf under the general direction of R. W. Crum, Director of the Board.

F. C. Lang, Chairman, is Associate Professor of Highway Engineering, University of Minnesota, and Engineer of Tests and Inspection, Minnesota Highway Department. He received the degree of Civil Engineer at the University of Minnesota in 1908. After two years with the United States Reclamation Service, five years as City Engineer, Chisholm, Minn., and four years as Superintendent of Construction, he took up his present work in 1918. Professor Lang is the author of numerous research papers and is active in the committee work of the American Society for Testing Materials, the American Association of State Highway Officials and the Highway Research Board.

Fred Burggraf, Special Investigator, received his training in chemical engineering at George Washington University. His technical experience includes three years as assistant chemist with a Portland Cement Company, three years with the United States Bureau of Standards and eight years in charge of research work on concrete and allied subjects with the Illinois State Highway Department. Mr. Burggraf has been loaned to the Highway Research Board for this work through the courtesy of Frank Sheets, Chief Engineer, and V. L. Glover, Engineer of Materials of the Illinois State Highway Department.

Design and Construction Features That Make for Highway Safety

Conditions Encountered by the Pennsylvania Highway Department

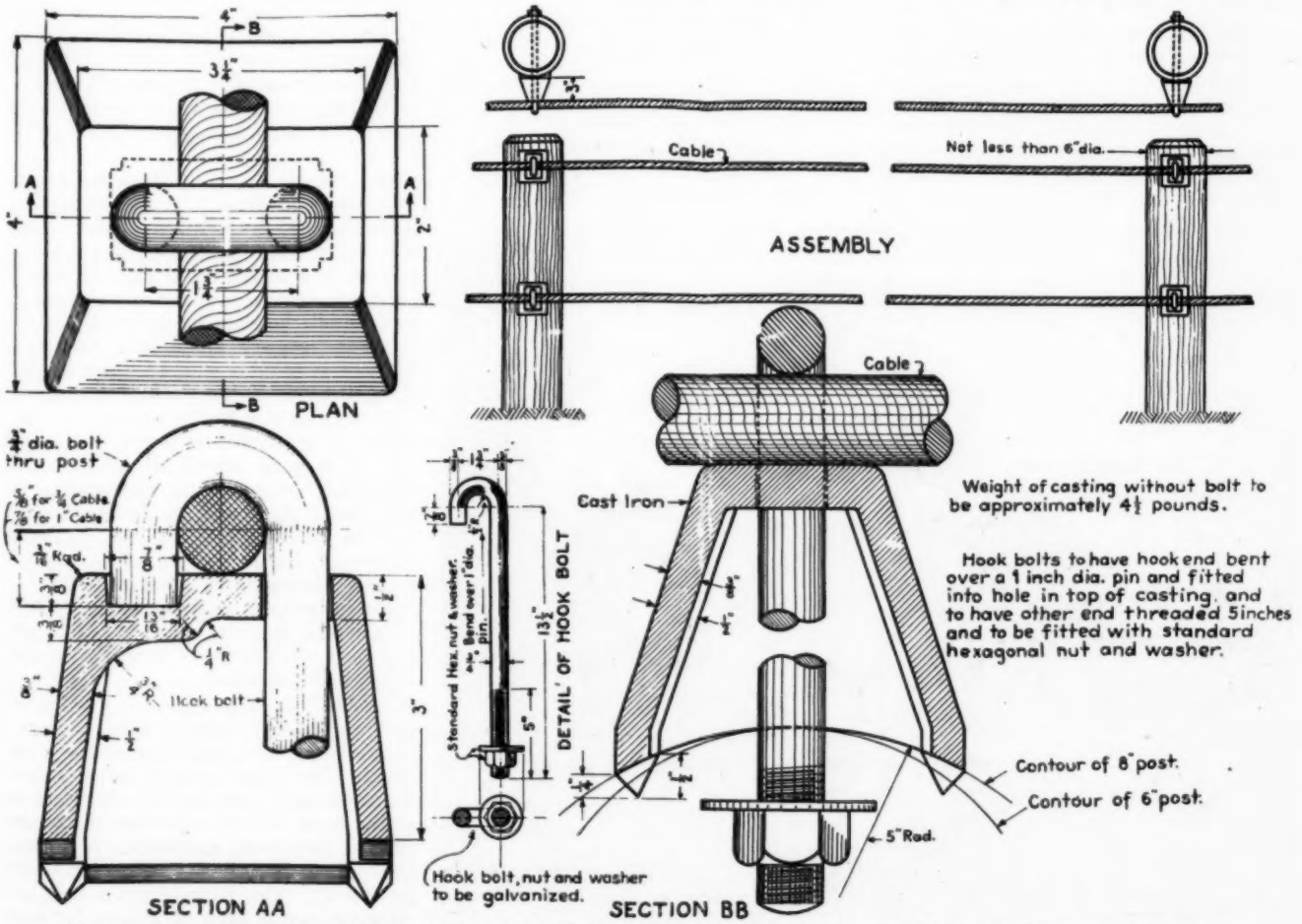
By C. C. ALBRIGHT

Office Engineer, Pennsylvania Department of Highways, Harrisburg, Pa.

SAFETY, as applied to a highway, cannot be defined in absolute terms but must be considered on a relative basis. Traveling in a motor car at 40 miles an hour may be safe with a certain combination of alignment, gradient, weather, traffic and driver, while 10 miles might not be a safe speed under other conditions. Danger is not alone confined to speed as a very slow speed of vehicle may introduce or be the cause of danger at certain times. This may be the case when traffic is particularly heavy. The average driver becomes impatient if forced to follow a slow moving vehicle and in an endeavor to pass it will take chances of colliding with other vehicles. The factors that influence safety problems are so varied and numerous that no complete solution is possible. The various points to be considered, however, are generally applicable to all highways.

The remainder of this discussion will be confined largely to the conditions encountered in the work of the Pennsylvania Department of Highways. At the present time all phases of the problems involved in safe location, construction and maintenance are given careful study and consideration prior to the preparation of construction plans.

Location.—A road should be relatively straight when the topography permits construction at reasonable cost. Curves and grades should be as light as practical. From an analysis of 1,277 traffic accidents which occured in 1926, and which were scattered throughout the state, the following comparison was made: Assuming the number of accidents on a straight comparatively level road to be 100 per cent, there was the same percentage on straight road with light grades, 105 per cent on light curves, 875 per cent on sharp curves and 508 per cent on steep grades. Light curves were assumed to be less than 10 degrees and light grades less than 6 per cent. This analysis indicates clearly the extra hazard on sharp curves and steep grades. It is the policy, where practicable, to hold the curves to a maximum of 5° 44', radius 1,000 ft. and the grades to a maximum of 6 per cent. On some mountain routes 8 per cent grades are used with lighter grades interposed at intervals of 2,000 ft. or less. From traffic studies which the department made, the desirability of breaking maximum grades at intervals with lighter grades in order to enable the driver to retain proper control of the car on descending and to prevent un-



Plan, Sections and Assembly of Offset Attachment for Standard Guard Fence Used by Pennsylvania Department of Highways

due slow speed in ascending was clearly demonstrated.

The combination of line and grade is given particular attention. Sharp curves at the bottom of long or heavy grades, or at the end of long tangents are very undesirable. These combinations can be avoided many times by more careful study of the location, but when relocation is impracticable because of difficult topography and excessive cost, a special design should be devised to reduce the danger. An example of such a problem and the solution is found on Pennsylvania Legislative Route No. 29 in the Seven Mountains of Mifflin County. For many years there was a hairpin turn on a very steep grade which was the scene of many accidents. When this route was improved in 1926 with a hard surface pavement the hairpin turn was expanded to a 25-degree curve, the pavement was widened to 30 ft. with a curb on the outside and standard shoulder on inside and superelevated 1 in. per foot of width. As a result of this design no accidents have been reported at this point since the construction was completed.

Reverse curves with little or no tangent between them are dangerous. We require a minimum tangent of 150 ft. between curves in opposite direction, but endeavor to adjust the alignment to secure a greater distance.

Sight Distance.—A minimum sight distance of 400 ft., assuming the line of sight to be 5 ft. above the road surface, has been required on all vertical and horizontal curves and at under and over crossings of railroads. However, with the present tendency of highway speeds of vehicles, this is not sufficient and the standard must be increased. I recommend 500 ft. as a minimum wherever possible.

Superelevation.—To promote the comfort and pleasure of the motorist and to increase safety by eliminating or reducing the tendency of the vehicle to skid, curves should be superelevation. The minimum curve to be superelevated and the rate of superelevation are debatable points. At present the policy in Pennsylvania is to superelevate curves sharper than 2° 52′, radius 2,000 ft., ½ to ¾ in. per foot width of pavement. In exceptional cases only is 1 in. per foot superelevation used. Theoretical values of 1 in. or greater are justified on sharp curves for high speed vehicles, but a slowly moving car or truck may skid or slip toward the inside of the curve when the pavement is coated with sleet or snow. The tendency in recent years has been to superelevate curves of smaller degree, particularly where the curves are long, than was formerly deemed necessary. I believe the policy will be extended in the comparatively near future to curves of 2 degrees and possibly to 1 degree.

Widening of Curves.—As the degree of curves increases, danger is created by the "overhang" of vehicles. Therefore, to provide safe clearance the pavement should be widened. Our practice is to widen pavement on curves of 9° 32′, radius 600 ft., or over from 2 to 6 ft. I believe this widening should begin with curves of 8 degrees, radius 716+ ft.

Crown.—A high crown is not only undesirable and unnecessary on any road with modern methods of construction and maintenance but also it may become a positive danger. On hard surface roads the crown should be sufficient only for proper drainage. Our standard is 1 in. for surfaces 18 and 20 ft. in width. Additional widths on the sides are sloped not to exceed ¼ in. per foot. On widened curves the crown is removed and a straight surface is used.

Pavement Surface.—The surface of the pavement should be finished true and free from humps and hollows. It is common practice to allow a vertical tolerance of ¼ in. in a longitudinal distance of 10 ft. This variation can be, and often is, greatly reduced by proper attention to the details of finishing.

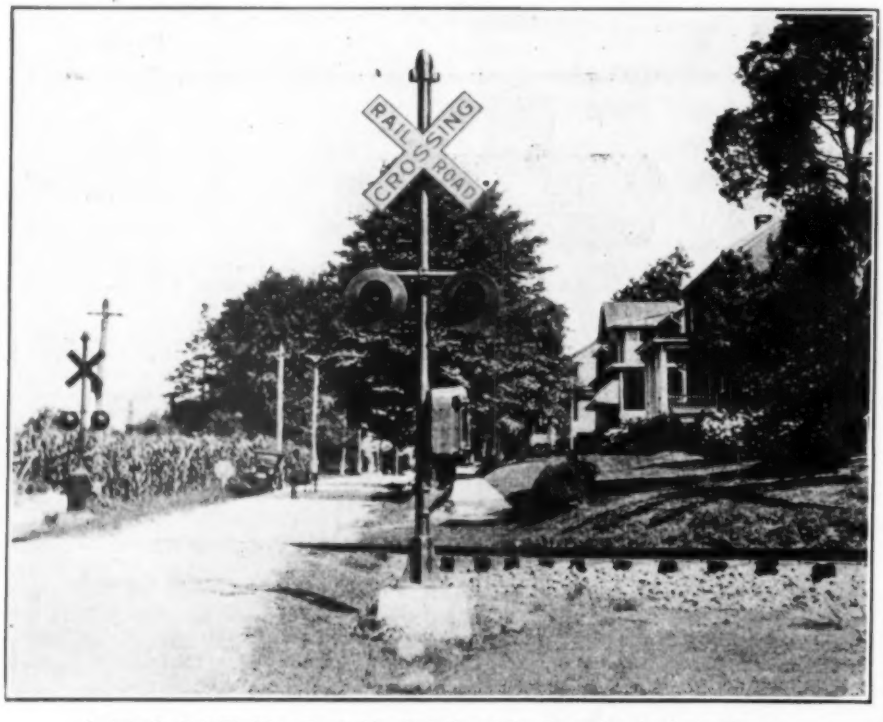
The surface of new pavements is checked by a car equipped with a mechanical device to indicate the roughness. This permits a comparison to be made of the surfaces on different pavements and promotes uniformity of results throughout the state.

In the case of a concrete pavement a natural belted or wood float finish is required, which leaves a slightly granular surface rather than the old style smooth sidewalk finish. On very steep grades, concrete with a broomed surface, hillside or brick with wire cut surface up, or a special open surface bituminous pavement may be used to give better traction and to reduce the danger of slipping or skidding.

Under particularly adverse weather conditions, when snow and sleet occur, any type surface may become slippery and dangerous for traffic. This is a maintenance matter and is remedied by spreading cinders or sand on the pavement.

In order to increase the convenience and safety of driving in the winter our snow program includes about 8,800 miles of roads. Temporary snow fences are erected where much drifting would occur. Maintenance forces are organized and mobile equipment is ready at all times to remove snow from the road surface as soon as a snow storm begins. On first removal the snow is plowed out approximately 3 ft. from edge of pavement. This provides room for snow on subsequent removal without encroaching on edge of pavement. It also keeps the road surface free from melting snow. The cost of our snow removal for a normal winter is approximately $100 a mile, or about 50 ct. per vehicle licensed in the state. Prevention is better than later remedies and the cost, we believe, is more than justified by the results.

Shoulders.—The shoulders or berms should be well constructed and maintained level with the edge of the pavement. The slope away from the pavement should not be so great as to cause a vehicle to overturn if it runs off the pavement, nor should it prevent the vehicle from easily returning to the pavement. The Pennsylvania standard shoulder has a drop of 1½ in. for each foot of width. This slope is carried to



Automatic Red Flashing Track Circuited Signal for Pennsylvania Grade Crossing

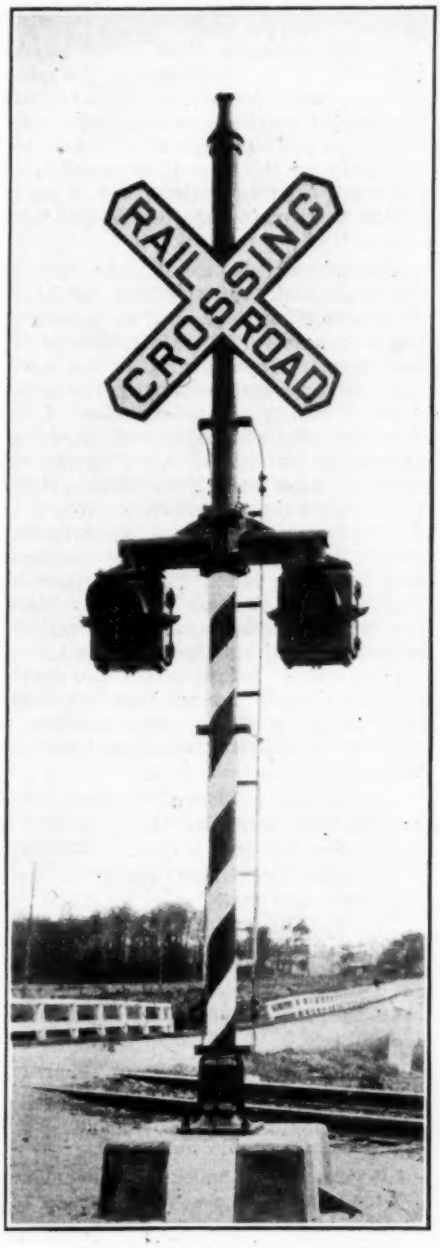
the ditch line or to the edge of excavation or embankment slope. When necessary on steep grades to carry surface drainage in excavation adjacent to the shoulder for several hundred feet, our present policy is to construct a paved shoulder with integral curb on the outside. This eliminates the danger of a soft shoulder and virtually provides an extra lane for travel. The ideal shoulder should be composed of a material that has sufficient stability to resist normal erosion and strength to support the wheel loads that may come on it. I believe that in general shoulder construction and maintenance have not been given the attention by highway officials that they deserve. Many accidents are caused by wheels of vehicles sinking into a soft shoulder or by the wheels skidding on the edge of a hard surface pavement where the shoulder is not maintained level with the pavement.

Where there is a large amount of traffic on the road the capitalized cost of an extra foot of width of pavement on each side should be compared with the cost of shoulder maintenance. Often it will be found that the increased safety to travel and decreased cost of maintenance fully justify the wider pavement.

Pavement Widths.—To provide safe clearance between passing vehicles, pavement should be not less than 20 ft. in width on main highways, thus providing 10-ft. lanes. Eighteen feet should be the minimum on secondary roads where there is very little truck traffic. The safe width is influenced not only by the size and number of vehicles but also by the speed. As traffic increases beyond the capacity of 2-lane pavements, one or more additional lanes should be provided. In Pennsylvania both 30 and 40-ft. pavements have been built on some of the main highways in recent years. Contrary to the opinion expressed by some engineers, we have not found 3-lane roads to be more dangerous than 4-lane roads, but full traffic benefit will not be realized and danger may result unless the traffic lanes are defined by proper marking on the pavement or by longitudinal joints.

Longitudinal Joints.—Concrete pavements are usually constructed with a longitudinal center joint. Where the surface is more than 2-lane width a longitudinal joint is formed between each lane. This joint acts as a safety factor in preventing irregular longitudinal cracking of the pavement and also when filled with bitumen serves as a stripe or guide to traffic. If there is no longitudinal joint in the pavement, the traffic lanes may be defined by painted stripes. Experiments have been made by inserting metal disc, bricks or colored blocks in the surface, but the results have not been entirely successful.

Guard Fences.—On both sides of high embankments or on the outside of curves or embankments, where a vehicle would probably overturn if it should suddenly swerve from the road, guard fences are erected. Wooden guard fences are dangerous and are obsolete on modern highways. Our standard fence has wood posts spaced 10 ft. apart, which carry two ¾-in. steel cables supported on cast iron brackets 3 in. from the face of the posts. At particularly dangerous points the upper cable is 1 in. in diameter.



Close-up of Grade Crossing Signal

Bridges.—Bridges are designed for a truck weighing 20 tons. The legal limit is 13 tons. Therefore, ample provision is allowed for impact or possible increase of the legal limit in the future. Small bridges, without sidewalks have a minimum 24-ft. clear width of two lanes of travel. On primary routes the minimum width is 30 ft. It is probable that these widths will be increased in connection with a revision of standards in the near future. Where a bridge is near a borough, village, church, school or closely built-up settlement, a 5-ft. sidewalk in addition to the widths just noted is provided at the expense of the commonwealth. If a bridge or viaduct is situated adjacent to a curve, or is on a curve, high parapets or through plate girder construction that would limit safe sight distance are not permitted in the design.

In order to prevent the settlement which may occur adjacent to the abutments of bridges from causing an unpleasant or dangerous sag in the pavement the approach slabs are reinforced by bar mats. If a large shrinkage of the embankment is expected a temporary type surface is placed until the embankment becomes stable.

Culverts.—It is the present policy to extend pipes or small culverts, where the cost is not greatly increased, to provide 10-ft. shoulders for future traffic lanes. Headwalls can be omitted usually on outlet end of pipe by lengthening pipe one or two joints. The longer pipe culverts prevent the danger of a bottleneck at these points and make provision at small additional expense for future widening of the highway.

Elimination of Railroad Grade Crossing.—Grade crossings of steam and electric railroads constitute one of the greatest dangers to highway traffic. Any factor that impedes the free movement of a motor car over such crossing creates an additional hazard. It is essential, therefore, that the alignment and grades adjacent to the crossing should be light and free from obstructions. Curves should not exceed 6 degrees and grades should be less than 6 per cent. The crossing proper should be paved or planked smoothly or uniformly for a width preferably several feet wider than the paved highway. Where the traffic is heavy on both railroad and highway, grade separation is given consideration. Where the approach to a grade separation is dangerous a "continuous flashing slow signal" is placed so as to be visible to approaching traffic at least 400 ft.

In Pennsylvania the average cost of the separation of grades is perhaps in excess of $60,000. This precludes the possibility of a complete separation of grades unless the operations are extended over a long term of years. It is doubtful also if the separation of all grade crossings could be justified. Efforts must be directed, therefore, to the elimination of the more dangerous situations and to better and more effective warning signs for the crossings that remain.

In this connection it may be of interest to know that the Pennsylvania Department of Highways, the Public Service Commission and such railroad companies as may become parties thereto have agreed upon the establishment of a uniform type of warning signal. This is an "Automatic red

flashing track circuited signal." It is installed and maintained by the railroad company. The Department of Highways pays one-half of the cost of installation. When a full view of these signals is less than 500 ft., an additional "Advance warning continuous flashing yellow signal" is placed along the highway within 300 ft. of the railroad grade crossing so as to be visible to approaching traffic at least 500 ft. This is installed and maintained by the Department of Highways, the railroad company paying half the cost of installation.

Eliminating a crossing or avoiding it for through traffic can be effected sometimes by relocating the highway, the railway, or both.

In the separation of grades, the choice of an underpass or an overhead crossing depends largely upon the topography in the locality. Our underpasses are designed for a minimum vertical clearance of 14 ft., which requires 18 to 20 ft. from finished grade to base of rail. The minimum width is 24 ft. All underpasses provide for at least a narrow sidewalk outside of the paved roadway.

A crossing over a railroad requires a gross vertical distance of 26 ft. or more in order to provide the necessary net clearance of 22 ft. from top of rail to underside of structure.

Elimination of Highway Grade Crossings.—The elimination of grade crossings on important highways is receiving attention of highway officials. Except where the volume of traffic is very great, usually in or adjacent to large cities, it has not been considered economically justified. The most notable examples at present are the Lake Shore Drive at Chicago and the New Jersey approach to the Holland Tunnel under the Hudson River. No doubt this problem will be given increasing study within the next few years.

Pedestrian Subways.—Where there is a great volume of pedestrian traffic crossing a street as in the vicinity of large schools, it may be desirable to decrease the danger to pedestrians and the slowing up of traffic by providing pedestrian subways. These have been confined to city or suburban locations of heavy population. Under the existing laws, our department is prohibited from participating in the cost of such structures.

Road Intersections.—Often the danger at road intersections can be greatly lessened by changing the grade on one or both roads, by relocating the intersection or by widening or daylighting the intersection. We have secured very favorable results in some cases by the widening of the intersection and rounding off the corners in one or more quadrants in order to better accommodate turning traffic. The curb radius of intersections should never be less than the minimum turning radius of a large passenger car or truck.

In Pennsylvania there is a special law relative to "Authorizing the purchase or condemnation of unobstructed view at intersections of highways, railroads and railways and at curves." By authority of this law it is possible to eliminate existing obstructions to sight and to prevent the erection of any new obstruction.

Conclusions.—It is entirely beyond the possibilities of the time available at this meeting to go into all phases of highway safety. Therefore, this paper has been confined largely to the more common problems arising in the processes of design and construction. I believe that the possibilities of providing reasonable safety for the traveler on the road have been made clear. However, as previously indicated, safety is a relative condition and road design which is safe today may need modification in a few years. The engineer or highway officials who design or plans his work on the basis of bare immediate necessities and cost and does not plan for reasonable future safety and development of traffic can not hope to remain long in his position. In conclusion, I wish to emphasize the importance of the following items:

1. Safety is dependent upon several factors, including the driver, car, speed, weather and design of highway.
2. Location of road, i. e., relation of alignment and grade.
3. Adequate sight distance.
4. Proper superelevation of curves.
5. Extra width on sharp curves.
6. Minimum crown of road surface.
7. A road surface free from inequalities and not slippery.
8. Shoulders properly constructed for safety of stable materials.
9. Adequate width of pavements for modern high speed vehicles.
10. Traffic lanes properly marked or defined.
11. Safe guard fences.
12. Wide bridges with safe approaches.
13. Pipe culverts of adequate length to give full roadway width between headwalls.
14. Elimination of railroad grade crossings where practicable.
15. Proper warning signs where railroad grade crossings are not removed.
16. Study possibility of eliminating highway grade crossings in exceptional cases.
17. Practicability of pedestrian subways.
18. Safe road intersections.

Acknowledgment. — The foregoing paper was presented Jan. 22 at the 15th annual Purdue Road School.

Southeastern Road Show and Conference

The Florida State Association of Boards of County Commisioners became interested jointly with seven other organizations in the sponsorship of the Southeastern Road Show and Conference, which will be held in Jacksonville, Fla., March 19-23, when they unanimously adopted a resolution expressing their interest in this enterprise, the local headquarters of the show was advised today.

Other organizations sponsoring the show are: University of Florida (Engineering College and Extension Division), Florida State Road Department, Florida Paving Contractors' Association, Florida Engineering Society, Jacksonville Engineers' Club, Florida League of Municipalities and the Jacksonville Chamber of Commerce.

The addition of the county commissioners' organization gives the Southeastern Show and Conference endorsement by all organizations in Florida interested in road, street and bridge construction and maintenance. The resolution was adopted at the Panama City meeting of the county commissioners' association.

Invitations to send their engineers and road and bridge superintendents to the show have been extended to more than 600 counties in the eight southeastern states and an exceptionally large attendance of county officials is being anticipated.

Reduced railroad rates are available over all roads and from all stations in Florida, Georgia, Alabama, Mississippi, Tennessee, Virginia, North and South Carolina, on the certificate plan, the Southeastern Passenger Association has announced.

Ike Parrish, 915 Greenleaf and Crosby Bldg., Jacksonville, Fla., is secretary.

Motor Vehicle Tax in Bavaria for Road Purposes.—The motor vehicle tax in Bavaria is divided between the State, the Districts (Bezirke), and the Communes in the percentage of 55, 27 and 18. It is entirely applied to road maintenance and road building. In the Extraordinary Budget appears an item of M. 18,000,000 for road building, to be borrowed immediately and repaid from the proceeds of the motor vehicle tax. This tax, the Minister thinks, should be raised, and he evidently has great faith in its increasing productivity. He cites figures to show that on July 1, 1928, there was:

	One Car for Every
In the Reich	68 persons
In Bavaria	65 persons
In Munich	35 persons
In Berlin	54 persons
In United States	5 persons

Economics of Snow Removal on Highways

Why 12-Month Roads Are a Necessity

By C. L. MOTL

Assistant Maintenance Engineer, State Highway Department of Minnesota

IT IS only because snow removal is something new, that anyone thinks of questioning the need or the value of keeping highways open in winter. If we forget the arguments which were valid ten years ago, and consider the question purely upon the basis of the present day use of motor vehicles and the present day investment in roads and vehicles, it becomes not a question as to whether we shall keep the main roads open, but only a question as to how far it is profitable to extend the snow removal program.

Motor Vehicles Increase Five Fold.—Ten years ago the answer would have been entirely different. In 1917 there were 4,657,340 passenger cars and 326,000 trucks registered in the United States. In 1927 there were 20,230,429 passenger cars and 2,896,886 trucks registered. In ten years motor vehicles have not only increased five fold in numbers but their use has entirely changed. Ten years ago the passenger car was correctly named a pleasure car. It could be used only in dry weather in summer and fall. We could not depend on it for daily use in our business or social appointments. The trucks then in use were nearly all in the cities.

In ten years, through state and federal participation in road building, we have not only greatly increased the mileage of surfaced roads, but we have connected these roads into a national system and established regular maintenance. The automobile manufacturers have also made their machines more dependable. The automobile today enters into the daily life of almost every family, taking us to and from our work, taking us to church and school and the theater and every other place we want to go. Since we have become accustomed to using our roads every day nine months of the year, it is wholly logical that our roads should be kept open the remaining three months.

Investment in Motor Vehicles.—Our investment in motor transport today is entirely too large to permit it to stand idle when snow blocks the roads. In Minnesota the investment in cars and trucks, highways, garages, filling stations and other related industries, is estimated to be more than a billion dollars. The original cost of the 660,000 motor vehicles registered in Minnesota alone is greater than the valuation placed by the Interstate Commerce Commission upon all the railroad property in the state. The ratio might vary in some states, but I believe there are very few states where the investment in motor transport is not greater than in railroads and equipment.

In volume of traffic also the motors have assumed an importance comparable with that of the railroads. In 1920, when railroad travel was at its peak the total for the United States reached 46,848,000,000 passenger miles. Assuming that the average motor vehicle travels 5,000 miles a year and carries 2½ persons, we find that motor travel in 1928 runs up near 350,000,000,000 passenger miles, nearly eight times as great as the heaviest travel carried in one year by the railroads. The volume of freight carried by trucks so far is only a fraction of that carried by the railroads, but it is nevertheless important. Farmers, merchants, manufacturers, every one, in fact, is more or less dependent today upon motor transport for shipping his products and obtaining his supplies.

Winter Traffic Large.—The volume of winter traffic today, where roads are kept open, is just about as large as the volume of summer traffic eight or ten years ago. If the large scale road programs then undertaken were justified to serve summer traffic, we are fully justified in a compliance with demands that roadway service be extended to 12 months of the year. All the arguments that applied to the need of better highways ten years ago, will apply to the need of open winter roads today.

Commercial traffic, such as trucks and busses, is only a part of our highway traffic, but if the bus and truck lines are to serve the people they must have open roads the year around. If they were to keep the roads open themselves, they would have to pass the cost on to their customers in the form of higher rates, so the public would pay for opening the roads just the same.

Besides the direct benefits to every automobile user, and that today means almost everyone in our nation, keeping the roads open in winter indirectly affects every industry and every human activity. It affects the railroads, for they are to a large extent dependent upon automobiles and trucks to bring their freight and passengers to their depots or cars. Most of the passenger travel and at least part of the commodity hauling on the highways is new business, and only a part of it is business which has been taken away from the railroads. In return for what the highways have taken away from the railroads, they have given the railroads much new business, business which would not be profitable to haul unless there were trucks and highways to bring it cheaply to the railroads.

Motor Transportation.—Motor transport has greatly changed the character of business handled by the railroads. Carload freight business and long distance, sleeping car, passenger business, have been steadily increasing. Motor vehicles, however, have relieved the railroads of a very large part of their short haul passenger business and their short haul, less than carload, freight business. But whenever the highways are blocked, this short haul passenger and freight business is thrown back on the railroads. If we are going to demand that they handle this business satisfactorily, they will have to maintain an organization and much equipment which will be idle nine or ten months in the year. This would necessarily require higher average rates than when the business is fairly constant in summer and winter. But no matter how good service were provided, it would be an inconvenience to shippers and travelers to change their method of transportation for a short period.

Advantage of Winter Roads to the Farmers.—When the farmer used horses for all his hauling, it required no large additional investment to change from wagons to sleighs in winter. Today almost every farmer has one or more passenger automobiles and owns or rents trucks to haul his products to market. The automobile has become as much of a part of the daily routine to the farmer as it has to the city man, and the farmer has no street car to fall back on when he cannot use his automobile.

Hauling grain and other non-perishable products might wait until the roads are open, but it is an advantage to the farmer to be able to haul his products to market whenever he has the time and whenever the market is favorable. But with perishable products, such as milk and cream, butter, eggs and poultry, it is absolutely necessary that they be brought to market at frequent intervals. The handling of this class of products has in the last few years been organized almost entirely on a motor truck basis, and to change to a sleigh and rail basis for two or three months in winter would be much more costly and very unsatisfactory both to producer and consumer.

What Open Roads Mean to Mer-

chants.—Open roads in winter mean very much to the merchants, especially in the smaller cities and villages. Before motor vehicles came into general use, farmers quickly changed from wagons to sleighs when snow came, and business was not greatly affected, but now merchants generally report that when a snow storm comes, their farm customers will not come in to town except for absolutely necessary supplies, until they can drive their automobiles. Good roads throughout the year are not only a stimulant to better business and a stabilizer of business, but at times open roads safeguard against an actual loss where certain seasonal goods are handled and sold. There are many instances where business men have opened highways at their own expense in order that traffic might flow more freely and customers come regularly.

The question of open roads affects labor. First of all its affects the winter employment. In so far as open roads assist commerce, manufacturing, transportation, construction or any other industry to maintain a steady pace during the winter, to that extent open roads help to solve the problem of winter unemployment. Open roads, permitting the use of busses and private automobiles, make it easier for the laboring man to go to and from his place of employment. In the industrial centers they make it possible for the laboring man to go to and from his place of employment. In the industrial centers they make it possible for the laboring man to live farther away from his place of employment.

The Country Doctor. — Open roads are necessary for the proper care of the sick and injured. The motor vehicle has greatly affected the medical profession. The old time country doctor is disappearing, and there are thousands of small villages which now have no resident physician. Good roads and automobiles have made it possible for the general practitioner to cover a wider area and to come quickly over long distance when called. Good roads have also made it possible to extend ambulance service and hospital care over districts which did not have such service before, but if we are to permit the roads to be blocked in winter, the residents of the farms and villages will be deprived of the medical facilities which they have in the summer time.

Open roads mean much to education. Today there are thousands of children all over this nation carried daily by motor bus to consolidated rural or village schools. If roads are not kept open, the transportation schedule will be upset, or schools closed. The number of students in high schools and colleges has increased very rapidly in the last ten years, and this growth has been greatly facilitated by good roads and automobiles.

So we might continue by pointing to many other phases of business and social life, and show the advantages of open roads to each activity. But the question arises as to the cost of keeping the roads open, and the effect of snow removal programs upon highway finances and upon the highways themselves.

Increased Use of Gas Pays Cost of Snow Removal.—In Minnesota we found that as far as the trunk routes are concerned, the additional gasoline tax which comes in through the winter operation of motor vehicles, more than pays the entire cost of keeping the roads open. Our entire snow removal bill last winter, which was an unusually severe winter, was $520,000, while the gas tax for the three winter months was $830,641. If the highways had not been kept open, there would have been no cars moving except in a few of the larger cities, and our gas tax would have been but a fraction of the amount we received.

But the $520,000 which we paid for snow fighting did not increase our total maintenance bill that much. In the first place, we would have had to keep at least part of our maintenance organization through the winter, and we will always have some maintenance expense. We would also have a much larger spring maintenance bill if the roads were not kept open in winter. We have found that wherever roads are graded to modern standards and snow is removed the full width of the road, so that the melting snow can drain into the ditches, the road is dry very soon after the first thaws in spring and usually remains in good travelable condition through the spring break-up. Where there are narrow cuts in old roads and it is not possible to open a wide path, the water from the melting snow may run into the center of the road. But these are exceptional cases, and they do not change the general rule that snow removal leaves the roads in better shape for spring travel and reduces the cost of spring maintenance.

Snow Removal on Secondary Roads. —How far can snow removal be wisely and economically extended to the secondary roads? This again is a question which is dependent to a large extent both upon the traffic and the plan of road financing in the different states. In Minnesota three-fourths of the counties are already keeping either all or part of their county roads open. I do not know of a single one which has tried it and quit, but each year new ones undertake the work, while others extend the mileage of roads they keep open. This still leaves the town roads to be considered, and so far there has been very little done towards keeping them open at public expense. Unlike summer maintenance, the cost of snow removal does not vary very much with traffic. On trunk highways it is of course necessary to open a wider path than on secondary roads, but it does not cost any more to cut a path on a county road carrying 250 vehicles per day than on a town road carrying possibly three or four cars a day.

In Minnesota 70 per cent of the population lives either in cities and villages served by trunk highways, or on farms within a mile of a trunk highway. The state aid and county roads are distributed so that the great majority of the farmers live within a mile of one of these roads and only a comparatively small number live more than two miles from a state or county road. It may be a long time before a method is found to finance organized snow removal on all the local roads, but I have noticed that when a state or county road is opened, the car owners living anywhere close to the road soon find a way of getting to it, and as soon as the state and county roads are opened, business in the small towns gets back very close to normal.

Ten years ago any general program of snow removal would have been waste and folly. Today it would be as much out of the question to permit the main highways to be closed in winter as to permit the railroads to cease operation during the snow period.

Acknowledgment.—The foregoing paper was presented at the 18th annual Road School of the Wisconsin Highway Commission.

State Highway Maintenance in Maine

Maintenance work during 1927 was performed generally by patrol maintenance. According to the recently issued annual report of the State Highway Commission, 500 patrolmen were employed in caring for 4,692.49 miles of road in 492 towns. Of this mileage 1,417.91 miles was improved state highway, 1,667.09 miles was improved state aid highway and the balance or 1,607.49 miles was unimproved road. There was also maintained by special arrangement with the towns 312.75 miles of improved state aid road.

A total expenditure for labor and material of $1,713,812 was made on this work, including $18,761.37 furnished by the state for road machine work. The state also furnished supervision and inspection for the work amounting to $50,007, making the total gross expenditure chargeable to maintenance of $1,763,819. Of this amount the state furnished $1,503,804 and the cities and towns furnished $260,015. The average expenditure per mile was $352.39.

On the 1,417.91 miles of improved state highway, the expenditure for labor, material and supervision was $1,225,821 or an average expenditure per mile of $864.53. The expenditure on the 3,274.58 miles of other road under patrol was for labor, material and supervision $521,311 or an average expenditure per mile of $159.20.

Securing Smooth Surfaces on Concrete Pavement Slabs

Operations and Equipment that Aid in Securing Desired Surface

By J. T. HALLETT

Assistant Chief Engineer in Charge of Roads, Indiana State Highway Commission

ALONG with the advent of the automobile together with the accompanying high speed traffic, there came the demand for smooth road surfaces. As the use of the automobile increased the demand was partially met by building some of the newly constructed roads with smooth surfaces (believed at that time to be very nearly perfect). Then along with the increased mileage of smooth surfaced roads came high speed, and with the higher speed came the demand for still smoother roads and so in this way the smooth surfaced roads and automobile speed has increased together until now they are both far ahead of what a few years ago, if considered at all, was considered impossible, or at best impractical. Few if any other type of road in the past have met the demand for smooth surfaces as completely as concrete.

In speaking of the smoothness of a road one might think of the general contour, that is, whether or not the grades were long and easy or steep with sharp vertical curves. Then again one might think of the surface texture, that is, whether or not the surface was smoothly troweled, polished or of a granular appearance. Then again there is the intermediate degree of smoothness which could neither be classed under grades nor surface texture. It is largely this intermediate classification that I will attempt to cover in this paper.

On contract work which seems to be the universal method of doing road work with public funds, the first steps necessary to secure a smooth surface on a pavement is to write in the specifications just how smooth the pavement shall be when completed. Then further, the specifications should require the use of certain methods of construction which have been tried and the fact well established that when followed they will produce the desired result. The specifications should go even farther and specify the major equipment and tools to be used.

Some states have had in their specifications a clause providing a penalty for each place the pavement fails to pass the test outlined in the specifications. This penalty in some cases has been some function of the unit contract square yard price, and in other cases it has been a flat rate of so much for each place the surface fails to pass the specified tests. I believe this has been functioned as a disciplinary penalty, and has had a good effect, but apparently has served its time, as recently the United States Bureau of Public Roads has required Indiana to remove this penalty provision from its specifications.

Indiana Specifications.—The specifications as adopted by the Indiana Highway Department covering the specific requirements on finishing concrete pavement surface and removing variations is as follows:

"Immediately after the pavement has been compacted and has received the initial belting, the surface shall be thoroughly tested for roughness by means of a ten (10) foot straight-edge laid parallel to the centerline, and all noticeable variations shall be eliminated.

The entire surface shall then be floated with a wooden float ten (10) feet long, having a face at least six (6) inches in width, of light construction, rigid and free from warps. The float shall be operated transversely across the pavement. After each operation it shall be moved longitudinally one-half lap. Care shall be taken to preserve the crown and cross section of the pavement. After the surface has been floated as described above, it shall again be checked with a ten (10) foot straight-edge and any noticeable variations shall be eliminated.

The surface shall also be tested by means of a template laid at right angles to the centerline. This test shall be made at intervals sufficient to insure obtaining the required pavement cross section, after which the final finishing shall be done with a belt.

Not later than ine (9) o'clock of the morning following the placing of the concrete or as soon as the pavement is hard enough to permit walking on it, it shall be again carefully straight-edged and all variations amounting to one-fourth (¼) inch or greater shall be plainly marked. The contractor shall, on the same day, eliminate such variations by the use of carborundum brick and water, but at no time shall more than 50 lineal feet of pavement be uncovered.

If any variations of one-fourth inch or greater remain after the above provisions have been complied with, they shall be removed by means of a power grinding machine, after the concrete has reached its approximate full strength, but not before the pavement is thirty (30) days old. The use of a bush hammer, chisel or similar device to remove variations in the surface will not be permitted.

Experienced concrete finishers shall be employed at all times in finishing, testing and checking the surface of the pavement. All belts used for finishing the concrete surface shall have minimum widths of twelve (12) inches. The edges of the concrete pavement shall be rounded with an approved edging tool having a radius of three-fourths (¾) of an inch."

This specification no doubt can be improved upon but it has been tried and has proven satisfactory.

In addition to the specific requirements there are a number of other operations and requirements which contribute greatly to the surface obtained.

Contractor.—First class results can not be expected nor obtained from a poor contractor regardless of the class of engineering and inspection given. Among the things that go to make a poor contractor are lack of sufficient finance, inexperience, obsolete, worn out or poor equipment, and an inefficient organization. If a poor contractor secures a contract all of these elements tend toward poor workmanship and are beyond the control of the inspector. As a guard against these things the bidders should be required to furnish financial, equipment and experience statements, and these statements taken into consideration to determine their qualifications for doing satisfactory work before the contract is awarded.

Progress.—Good results can not be obtained unless the concrete is mixed and spread at a fairly uniform and reasonable rate of speed. Extreme slowness or frequent stoppage breaks the continuity of operations with the result that the concrete can not be finished at the correct time in its setting up process, and some of the necessary details are likely to be omitted.

Mixer.—The mixer should be in first class condition so that the consistency of the concrete can be kept uniform. Uniform workability of concrete is one very important element necessary to secure a uniformly smooth surface. The most important devices of a mixer necessary to obtain a uniform consistency is an accurate water measuring device and a batch meter.

Forms.—The side forms should be straight and rigid and set true to line

and grade on a firm foundation. A very rigid specification and inspection on forms and their setting is necessary to secure a smooth surface. After the forms are set they should be checked with a straight-edge as carefully as the pavement. Less variation should be allowed in the forms than is permitted in the pavement surface because it is impossible to set forms at all times on a foundation without some give to it. If a ⅛-in. variation under a straight-edge is permitted in setting of the forms by the time the finishing machine comes over they are likely to have a ¼-in. variation.

Finishing Machine.—One can not expect first class work from a machine that is poorly designed, constructed or not adjusted, nor one which is old, worn and in poor working condition. Generally in the middle west there are only two makes of finishing machines used, and both under ordinary conditions will do good work. Before the start of each job the finishing machine should be gone over, worn parts replaced, and the machine generally placed in first class working condition. Occasionally during the progress of the work it should be checked for excessively worn parts.

Auxiliary Equipment.—If all the other equipment, operation and details which effect the surface of a pavement are correct and properly handled there would be little need for any auxiliary equipment, but this seldom happens for very long periods at a time. Therefore, if at any point the process fails, auxiliary equipment and hand work are necessary to correct the deficiency before the final finish is given and the concrete left to harden. The usual auxiliary equipment required are:

(a) A bridge that will span the pavement and can readily be transported from place to place;

(b) A strike-off and tamping template conforming to the crown of the pavement and having a metal face at least 4 in. in width. It shall be so constructed as to maintain the true cross section at all times;

(c) An extra finishing belt;

(d) Two or more long-handled 10-ft. straight-edges for checking green concrete and one 10-ft. straight-edge for checking concrete that has attained final set, all properly constructed from suitable material;

(e) Two or more long handled floats 10 feet long with a face 6 in. wide, of light construction, rigid and free from warps.

(f) Long-handled floats having a blade at least 5 feet in length and 8 in. in width.

The bridge and strike-off template is for use only in extreme emergency when the finishing machine fails and hand finishing has to be resorted to, to finish the concrete already mixed and placed. The extra belt is used for this purpose, also may be used for the delayed belting when the pavement is being laid rapidly and it is not desirable to bring the finishing machine back to do the last belting.

The 10-ft. straight-edges are the tools by which the roughness of the surface is determined.

The 5-ft. long-handled floats are used for removing uneven places in the surface of ½ in. or more which the machine finish did not get.

The 10-ft. long handled floats are used over all the surface to remove smaller variations and also aids greatly in assuring a surface which will check correctly under the 10-ft. straight-edge.

Lastly, after all finishing and checking the surface is found to be correct the surface is belted to give it the proper texture. This last belting should be applied after the surface has become a little sticky so that a granular surface is obtained.

Steep Grades.—When laying concrete on grades of 4 per cent or over, care should be used to give the concrete its last checking and finishing after it has hardened sufficiently that it will not roll and become rough after the final finish.

Personnel.—The form setters and finishers must be skilled and conscientious in their work to get good results. With an otherwise perfect organization if a form setter or finisher is inexperienced a rough surface is likely to be the result. An inspector that is willing to work and understand the importance of care and proper performance of all duties will help greatly in getting continuously good results. The purely political inspector is very often worse than none, although sometimes a man can be rewarded for his political efforts and also make a good inspector.

Another very important item in connection with the personnel is morale. The contractor's organization and the state's engineers and inspectors must have the proper respect for the rights of others. Personal good will can be promoted within the two organizations and better construction will result, not only on surface smoothness but on all features. It is a well known fact in the business world that no firm can continue in business very long without good will from others outside the organization. This is equally as important in the construction business.

With all of these factors working together an exceedingly smooth pavement should be the result but a failure in any one may produce the unsatisfactory result, so that the only means left to obtain a smooth surface is to grind down the hardened concrete which is the least satisfactory way of getting the specifications fulfilled.

Removing Rough Spots.—After the concrete has hardened the surface should again be checked with a straight-edge. If for any reason there still remains some rough spots they may be removed if only slight by rubbing with a carborundum brick and water. If after being rubbed until the coarse aggregate is reached the surface is still rough the only corrective is to wait until the concrete has reached nearly its maximum strength and grind with a power grinding machine. A few years ago bush hammering was permitted but is not now considered good practice.

It is a well known fact that the surface of a concrete pavement gets rough as it gets older. Transverse cracks form, unless joints are made frequently and the slabs heavily reinforced. The then separate slabs curl under temperature changes; soil and other material get into the open cracks and the slab never returns to its original position. It has not been determined at what age the limit of this progressive roughness is reached. It is very likely different for nearly every piece of pavement. The frequency of cracks, the frequency of temperature changes and the character of the sub-grade affect this action. The filling of cracks with bituminous material together with the sand or chips applied makes the surface of the pavement rougher.

It therefore appears that the surface of our concrete pavements can be kept smoother by preventing cracking as much as possible, by keeping the cracks well filled with a bituminous mixture instead of letting the cracks fill with earth or other firm material, and using care when filling cracks to prevent the mixture of bituminous material and sand from building upon the surface.

Common Requirement for Smoothness.—The most common requirement for smoothness of the surface of a concrete pavement at the time it is constructed is that there shall be no variations of more than ¼ in. when tested by means of a 10-ft. straight-edge laid parallel with the centerline of the roadway. Some believe this is not sufficient and require no variation of more than ⅛ in. when tested by means of the 10-ft. straight-edge.

It is possible to construct a concrete pavement that accurate but after considering the very short period the surface will remain that smooth after being exposed to the weather changes and traffic, it appears to be very doubtful if the extra care and expense are justified.

Acknowledgment.—The above paper was presented Jan. 11 at the annual meeting of the Mississippi Valley Conference of State Highway Engineers.

French National Highway Appropriation for 1929 Almost $34,000,000.—The 1929 budget, passed by the French Parliament in the closing days of 1928, carries the largest national appropriation ever made for roads and bridges. The total highway appropriation in the budget for 1929 amounts to 865,010,000 francs, which at the present rate of exchange amounts to approximately $33,900,000, an increase of more than 52 per cent, as compared with an increase of 16 per cent of last year's highway budget over that of 1927.

Pre-Qualifying Bidders

How It Has Worked on National Forest and Park Jobs

By DR. L. I. HEWES

Regional Chief Engineer, U. S. Bureau of Public Roads, San Francisco, Calif.

OUR experience during the past year in pre-qualifying bidders for National Forest and National Park road jobs has been satisfactory, not only, we think, to the Government, but to the contractors. This is evidenced by the fact that during the year 193 contractors applied for a rating, and 189 qualified. Not all of those qualifying submitted bids, but of those who submitted bids for the 98 projects awarded only one fell down completely after award, and only one other has shown decided signs of inability. These are some of the outstanding figures. Many contractors bid on more than one job. As a matter of fact, there were 470 bidders in answer to 100 calls for bids. There were 48 instances in which the contractors did not big after securing plans and questionnaire.

In keeping with the general policy of the Bureau of Public Roads, it has been our endeavor to avoid being arbitrary in any way in this matter of establishing bidders. We have issued general instructions to the several district engineers, and have granted them considerable latitude in interpreting the answers to the questionnaires. We have no particular criticism of the questionnaire approved and recommended by the Joint Conference on Construction Practices, but our experience has indicated that it certainly needs careful interpretation. Of course, as in any new procedure, certain unexpected elements have appeared during the year. I will indicate to you some of the questions that have arisen.

In the first place, owing to the short season and the corresponding obligation of starting work immediately when money is available, our lettings are condensed perhaps more than those of other highway organizations. Consequently we have opened bids in several instances for a number of successive days. Where there is a question of a contractor's capacity to handle more than a given amount of work, it is necessary to follow closely his bidding on successive days and see that he does not get overloaded. So if he is qualified for the first day's bidding only and should he be the low bidder he is automatically barred from further bidding. This, of course, is the marginal case where the contractor's financial resources are not unlimited.

What Should Be Contractor's Financial Resources?—That brings us to the general question of what should be the contractor's financial resources. Obviously they must bear some relation arbitrary. There have been a few instances where well known contractors, who have repeatedly performed, have been qualified with liquid assets equal to 10 per cent of the contract. This is somewhat exceptional. We have not yet, however, felt the necessity of demanding more than 20 per cent.

But this cash qualification must go hand in hand with other qualifications. Cash is necessary, but not sufficient, and no contractor without equipment or experience could qualify within the above range.

We frankly prefer contractors who do their own work and are not given to completely sub-letting the job.

We find that repeatedly a contractor loaded up with old, worn-out equipment, has a liability rather than an asset, and we have found that contractors not well equipped have not asked for questionnaires.

Presently I will read you some remarks of our district engineers on their experience in this matter. Let me repeat, however, that we are not applying an exact formula for analyzing the questionnaire. We are keeping the matter as flexible as possible and allowing judgment to be exercised by the district engineers. We are finding, for example, that if the contractor presents a general qualification, that qualification is sometimes impaired later by excessive bidding. We are finding also that contractors to whom the notice of opening of bids comes late are sometimes delayed (because of the details of the qualification requirements) in presenting their bids, and on a very few instances have failed to bid. We are watching these adverse elements carefully and hope to avoid trouble in the future from them. We think that the practice is bound to improve. Now for remarks from the district engineers, from letters written to the Regional Office:

Experiences of a District Engineer.—"We have rejected two questionnaires, one on advice from Washington, and the other because the contractor had too much work on hand. * * * Questionnaires were accepted with a limitation representing our ideas of the work that contractor could efficiently and satisfactorily handle. We have had a few cases of contractors who requested plans and who failed to file a questionnaire when told that they must do so. All of the cases, however, were small contractors who probably lacked the required experience and financial standing for the job in hand. * * * In our ratings we considered first, character and reputation; second, experience and competency. Experience and promptness and number of jobs handled at a time were all considered. Third, organization: Does he handle his work or sub-let? Has he experienced men? Is the organization sufficiently large to cover work under way and still take on new work? Does the contractor personally direct work? These questions are considered with the information in the questionnaire. Fourth, equipment. This statement is examined carefully because it appears again in the financial statement. The equipment must be suitable. Unsuitable equipment, even if new, can be given no credit. It is difficult from the statement to determine the exact condition of equipment. Fifth, financial condition. How much cash has he? How much does he owe? How much additional cash can he raise?

"Most contractors submitting answers qualify, but there are marginal cases where the governing principles must be applied. The contractor of good reputation, with good equipment and organization and good collateral, who is short of 20 per cent, we generally pass; we have approved some considerably below 20 per cent. But a contractor with cash and no other requirements is strictly limited in the amount of work, including other work already on hand. We believe the greatest benefit accomplished has been an indeterminate one; that is, the psychological effect on the marginal contractor which undoubtedly accounts for the few rejections. We have no suggestions for changes for at least another season."

What Another District Engineer Says: "We try to qualify approximately as follows: Determine the quick liquid assets and deduct liabilities, which should leave a reasonable percentage, probably 15, of the work to be bid, but this may vary with the adequate available equipment. The contractor with all the equipment necessary might not be required to show as large net cash assets as another only partly equipped or not equipped at all. The record of the bureau or in other highway organizations of the contractor's past performance on the particular work at hand is carefully considered. To give credit for real estate, its value must be determined and encumbrances deducted. We need to know its loan value. The listed value of equipment is of little consequence in comparison to the use value of the equipment for the job in hand.

"There is some difficulty after qualifying contractors for a limited amount of work, in determining how much they have bid in before bidding again with the bureau. Since contractors bidding on bureau work must now depend on advertisements only and not a mailing list, there were few cases where they were unable to qualify in sufficient time.

"It is a question whether some better method of checking contractors' statements as to finances should not be found. Banks and financial corporations demur at giving this information. We might turn away good contractors by being too insistent and also we might raise unfairly a question of their credit.

"The year's experience has, I believe, resulted in somewhat better qualified contractors."

Statement of Another District Engineer: "We require at least 10 per cent

liquid assets, combined with serviceable equipment. We are guided somewhat by our knowledge of the contractor's reputation for paying bills and completing work. We have had to raise the requirements on some previously unsatisfactory contractors. We had to reject one man who showed assets of $750 cash for a project estimated to cost $175,000. In fact, the $750 included the value of this contractor's equipment. No contractor has requested plans on which he was not qualified to bid. When contractors file questionnaires in advance, we cannot determine which job they intend bidding.

"We believe the questionnaire has discouraged some undesirable contractors whose past records were adverse."

Another District Engineer Says: "Financial and experience statements are received for each and every project which he bids in preference to blanket rating on a first review. We prefer this method since his finances, available equipment, and experience, is continually changing, as well as the projects. We prefer a financial status at the close of the month preceding the letting, but do not require a new financial statement unless there is some material change. We think that as a minimum, quick asets should be 10 per cent of the estimate, plus 10 per cent of all uncompleted work in hand.

The experience qualification is a matter of judgment, and related to the project in hand. Rarely a bidder, well financed but with little experience, is admitted on the understanding that he will employ capable superintendents. Sometimes he has experience without cash, and we have suggested that he ally with him necessary financial support.

"Sometimes we have restricted the bidding to one project, when the bidder desired to bid more. He may be given plans for several jobs, but bid forms for the jobs only in the order of opening.

"None have refused to submit the required statements, but some have failed to fill them out because of decision not to bid.

"I have only favorable comment from contractors and other interested parties.

"I raise two questions: (1) In case of a well known contractor with sufficient experience, particularly on bureau work, good record and reputation, but temporarily financially embarrassed, should we not show such a man considerable leniency over a totally unknown contractor in the same condition, and permit the former to bid if he can show that he is able to borrow? (2) Does not the present procedure hurt the man who has only sub-contractor or construction superintendent experience, but has finally acquired sufficient capital to undertake a contract of his own? Should not such individual be allowed to bid on small projects?"

Closer Contact Established.—In the above, I have taken you frankly into our confidence, as we believe that the success of this matter is dependent on thorough co-operation with the contractors as a body. We shall endeavor to perfect this procedure as far as possible. Certainly the past year has established a closer contact between the contractors and the district organizations in advance of proposals, and allows both parties to thresh out any misunderstandings, and certainly gives the bidder a better understanding of the bureau's requirements, and, like the California marriage license law, prevents contractors from rushing in at the last moment and making the contract without due deliberation. Only one contractor has protested a rating established by the bureau. The one case where a contractor failed to operate after qualification showed that his credit was tied up in obtaining bond. In this case the bonding company came forward with financial assistance, although the contractor did not default.

It may be of interest to you to know that in over 450 western contracts, in nine years, the bureau has had only 21 cases where the contract has been finished by another party. Sometimes, however, the surety has helped the contractor without his defaulting. In 1926 we had six defaulters, and one each in 1927 and 1928. We hope that next year there will, under our pre-qualification plan, be none.

Acknowledgment.—The above paper was presented at the Convention of the California Division of the Associated General Contractors of America.

Cost Figures on Highway Work in Saskatchewan

H. R. MacKenzie, Chief Field Engineer, Department of Highways of the Province of Saskatchewan, Canada, gives the following costs in the annual report of the department for the fiscal year ended April 30, 1928:

During the season of 1927, contracts were awarded for the construction of approximately 332.6 miles of road. The average price for earth excavation, on all contract work performed during 1927, was 21c per cubic yard. The total volume of earth excavated in connection with the improvement of the 2,876.2 miles completed to date is approximately 16,145,000 cu. yd.

The following table shows the average unit prices of the various classifications on all contract work performed during the period 1920-1927 inclusive, and also the average unit prices on contract work for the seasons of 1926 and 1927 respectively:

Classification	Unit	1920-1927 inclusive	1926 only	1927 only
Earth excavation	cu. yd.	$ 0.236	$ 0.213	$ 0.210
Loose rock excavation	cu. yd.	0.712	0.646	0.695
Solid rock excavation	cu. yd.	1.825	1.543	1.967
Overhaul	cu. yd. 100 ft.	0.038	0.040	0.040
Riprap	cu. yd.	2.052	2.026	1.534
Gravel surfacing	cu. yd.	1.158	0.886	1.499
Guardrail	lin. ft.	0.792	0.574	0.983
Clearing	acre	0.347	0.341	0.379
Grubbing	acre	27.589	23.300	27.096
		63.792	38.645	45.649

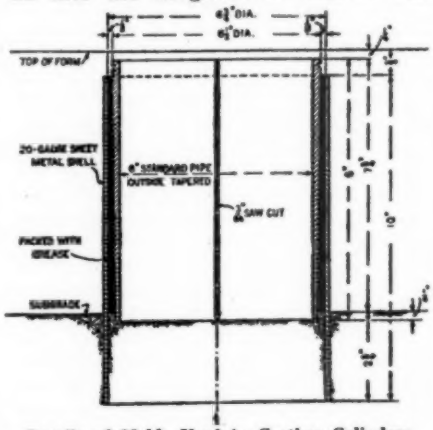
In addition to the work of completing 270.7 miles of new construction and 3.0 miles of reconstruction, we placed gravel surfacing on 8.3 miles and clay surfacing on 18.8 miles of road during the season of 1927. The total mileage of gravel surfaced road constructed to date is 72.6 and the total mileage of clay surfaced road is 126.0. The average cost per mile of grading and surfacing work performed during the period 1920-27, inclusive, is as follows:

	Per Mile
Grading (including culverts, etc.)	$2,444
Gravel surfacing (1,000 cu. yd. per mile)	1,554
Sand-clay surfacing (2,000 cu. yd. per mile)	2,278

Form for Casting Cylinders in Concrete Slabs

In connection with the field experiments in curing concrete pavement in Maryland* concrete cylinders for testing purposes were cast and cured in a test slab adjacent to the road. The accompanying sketch from February Public Road shows the details of construction of the form used for this purpose.

The outer shell was driven about 2¾ in. into the subgrade so that it was



Details of Molds Used in Casting Cylinders

firmly placed and the inner shell was adjusted so that its top was ¼ in. below the top of the slab forms. A coating of heavy grease between the two molds facilitated removal of the iron cylinder and a layer of grease at the top of the outer mold sealed the space between the two, preventing any leakage of mortar which would have made removal difficult. Slots at the top of the iron mold made possible its removal by chiseling through the ½-in. layer of concrete and then prying it out with two pinch bars bent at an angle of 45°. One person could remove these molds without difficulty.

*See Public Roads, Sept., 1928.

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What's Wrong With Our Colleges?

Research may be divided into two branches: (1) The gathering of data; and (2) ascertaining the significance of the data. Put in this form it is obvious that every business or professional problem calls for at least some research. But because scientific research laboratories have so frequently stressed the importance of discovering laws of nature, there is a prevalent belief that all research relates solely to discovering natural relationships and their cause. It is true, however, that the research methods used by scientists differ immaterially from those used by the most successful business and professional men; for in all cases the search starts with a review (or re-search) of published facts, and ends with an analysis that discloses their significance.

Take, for example, the problem of designing the most economic bridge for a given crossing. A thorough engineer first reviews designs that have previously been made for similar crossings. He collects data relating to many bridges, including cost data, for unit costs are the ultimate criteria of economy. He considers facts as to strengths of the latest discovered alloys. And since, for a long series of spans, that one is usually most economic in which the cost of the substructure is approximately equal to the cost of the superstructure, the engineer makes many soundings to determine the depth to which the piers must go. All this, and much more, is involved in the fact-gathering part of the research.

Next he comes to a study of the economic significance of the facts. He starts of course with the known principles of strains and stresses as his guide; but since human ingenuity is a flexible and important factor in designing anything, he is cautious about following any precedent too closely. Moreover, not only do physical conditions vary in different localities, but economic conditions often vary much more, so that blind copying of a previous design and specifications is certain to give a result less economic than one attainable by the use of intelligence. Guided by facts, guided by established principles, guided by analogies, the engineer makes several—often many—tentative designs before he is satisfied with the result. He "cuts and tries" again and again.

Note carefully that very little of this sort of practice is given in the typical college course in engineering, or indeed, in any branch of study. The lack of such research work constitutes the greatest defect in our educational system from primary school to college. It is futile to argue that the experience of after life will overcome this defect, for habits of thinking are practically fixed before the age of 25, according to the best psychologists. And, according to psychology, habit, next to instinct, is the most powerful determinant of action.

The successful business man attacks an economic problem in exactly the same way as does the successful engineer. He calls first of all for facts. Statistics of production and of consumption—these are the things without which his reasoning would be mere guesswork. And it is largely because so few business men fully realize the importance of this fact-gathering principle and have so seldom been trained to apply it habitually, that they succeed indifferently or fail completely. Often a business man sees a competitor's business grow steadily while his own languishes, and he merely marvels and grows envious at the growth without undertaking a careful search for the cause. Or if he seeks the cause of his competitor's success, he goes only so far as to make a few inquiries, and thus gets answers that are often erroneous and always incomplete.

Contrast such a method, or lack of method, with the practice of one of the most successful hardware merchants in Pittsburgh. Every summer he spends about six weeks travelling in his automobile from town to town interviewing other hardware merchants. When he enters a town new to him he asks several residents to direct him to the best hardware store. He presents his card to the proprietor and tells him how he was directed to him as the leading hardware merchant in the town. Then he proposes that they exchange experiences and ideas on hardware merchandising. He begins by telling how successful has been his sale of a certain new type of heater, one of which is mounted over the hood of each of his delivery wagons, with a placard stating some facts about it. The other merchant usually reciprocates with a similar experience. Within an hour or two, the interviewer departs laden with several facts new to him. "True," he adds, "my hardware magazines also do this sort of thing for me, and at far less expense; but their editors and contributors can not possibly secure all that is worth publishing."

When asked whether hardware merchants are usually students of hardware magazines, he replied: "Obviously not, for one of the good hardware magazines is sent free of charge to its readers. If all hardware merchants were very studious, that magazine could readily get $10 a year from every one of them, and I personally would pay them hundreds of dollars annually rather than be without it."

This brings us to a bit of evidence that strongly supports our inference that our schools fail to instruct students as well as they might. We refer to the universal difficulty encountered by publishers of trade and professional magazines in selling subscriptions. The same difficulty is encountered by publishers of books on business and professional matters.

The libraries where such publications are to be read free are never well patronized. And in few cities is there any library that is well stocked with business and professional books. As an instance, Los Angeles, a city of a million and a quarter people, has no library that can be designated as a satisfactory medical library. The physician that made this statement added that his own observation had satisfied him that not one doctor in ten read any medical journal conscientiously. We mention this because the medical profession, above all others, is charged with great responsibility to society. If its members are so indifferent to that responsibility, it can be attributed only to the lack of proper research training long enough conducted to make them life-long searchers for new facts and principles.

We engineers, however, should not criticize physicians on that score. Our engineering libraries, even in most of the large cities, are usually far behind the times, and never were adequate. Our private libraries are rarely adequate even in the special branch of engineering that we follow. We seldom bind any engineering periodical. We, too, as a class, have still to realize fully that scientific progress depends upon the constant gathering of facts, the interpretation of their significance, and the use of them in solving economic problems. Perhaps nearly all of us realize the truth of that fact, but do not act upon it because we were not trained as fact gatherers and interpreters. Are we not like so many men who concede the desirability of taking vigorous exercise for an hour or more daily, but fail to exercise because they have never become so habituated to exercise that they feel ill at ease without it?

Einstein's Deduction of Relationship Between Gravitation and Electrodynamic Forces

In 1836 Massotti announced the hypothesis that gravitation is due to a slight excess of electric attraction over electric repulsion in all particles of matter, but his hypothesis was never established either theoretically or by experiment. About the same time Gauss, a German scientific genius, showed mathematically that the interactions of two magnets could be explained if each element of magnetic charge repelled each like element and attracted each unlike element with a force proportional to the product of the charges on each element and inversely as the square of their distances apart. Since Newton's law of gravitation is of exactly the same mathematical form as Gauss magnetic law, it must have impressed all thoughtful physicists that this agreement indicates a strong kinship between gravitation and magnetism. When Einstein proved, 24 years ago, that energy has gravitative mass, it became more probable that the energy known as magnetism differs from gravitation only in intensity and in some directional way.

Not many scientists know how exceedingly weak is the force of gravitation compared with the force of static electricity. Richardson ("Electron Theory of Matter," p. 590) shows that the electrical attraction of an electron is to its gravitational attraction as 0.25×10^{42} is to 1; or the electric force is 2,500,000,000,000,000,000,000,000,000,000,000,000,000 times the gravitative force. It is largely ignorance of this enormous disparity between electric and gravitative force that accounts for the apathy of astronomers relative to any electromagnetic or electric theory of sunspot genesis, and the like. Perhaps Einstein's recent discovery will serve to dispel this apathy.

Relative to a direct quantitative relationship between gravitation and electricity, perhaps the first one to be published was the formula given in "Engineering and Contracting," January, 1928, in an editorial article entitled "The Etherite Theory of Matter." The formula is

$e = 3r\sqrt[4]{G}$.

e = electric charge of an electron = 4.77×10^{-10} e. s. u.

r = radius of an electron = 10^{-13} cm.

G = gravitational constant = 6.66×10^{-8} C.G.S. units.

We quote from the article: "Atoms have long been known to be composed of electrons. It is but another step to the hypothesis that electrons are, in turn, composed of particles which may be called etherites. Some of these etherites are constantly escaping from every electron, and the number escaping is always greatest in the direction of least external pressure. This unbalanced, or assymetrical, escape of etherites produces motion of the electron in a direction opposite to that of the escaping etherites (because of the reactive push). Etherite radiations from an electron produce unbalanced pressure upon other electrons, and thus cause gravitational effects. Hence gravitation and inertia are similar phenomena. Perhaps the most important new formula thus far deduced by aid of the etherite theory is one giving the electric charge on the electron (the formula above given), for the etherite theory shows the electric charge to be due to the escape of etherites from a rotating electron, and the etherite theory connects electric attraction directly with the gravitational constant.

The etherite theory of gravitation and inertia was first outlined in "Engineering and Contracting," Sept. 9, 1925. Up to that time the electron had never been broken up, but on Dec. 30, 1927, Davisson, of the research staff of the Bell telephone system, announced his having broken up electrons into "waves." Now comes Einstein with a mathematical correlation of electricity and gravitation based on his theory of relativity.

To the editor it has long seemed probable that back of Einstein's mathematics there must be hidden physical activities of the everyday sort; and that if these could be properly apprehended the mystery of inertia, gravitation and electric force would vanish. It was this belief that led to the etherite hypothesis, and the subsequent mathematical deductions from it.

It is interesting to observe the acclaim that greets Einstein's announcement of his new theory, even before its publication, and to contrast the attending publicity with the silence that greeted his first epochal paper 24 years ago. That paper contained a great discovery, but for 14 years it remained almost unrecognized even by the scientific world. We scientists should not have too exalted ideas of the extent and profundity of scientific education when such a scientific biography as Einstein's is part of the history of our own generation.

H. P. Gillette